SHRI BRAHMAGUPTA VIRACITA

BRĀHMA-SPHUṬA SIDDHĀNTA

WITH

Vāsanā, Vijñāna and Hindi Commentaries

Vol. I

FOREWORD

By

DR. SAMPURNANANAD

Governor-Rajasthan

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Shri S. K. Patil

Union Minister for Railways

श्रीब्रह्मगुप्ताचार्य-विरचित

ब्राह्मस्फुटसिद्धान्तः

(संस्कृत-हिन्दी-भाषायां वासनाविज्ञानभाष्याभ्यां समलंकृतः सोपपत्तिकः)

प्रथमो भागः

प्राक्कथन :

डा० सम्पूर्णानन्द-राज्यपाल-राजस्थान

प्रधानसम्पादक :

आचार्यवर पंडित रामस्वरूप शर्मा

(सञ्चालक-इण्डियन इंस्टीट्यूट आफ् ऐस्ट्रानौमिकल एण्ड संस्कृत रिसर्च)

प्रकाशक :

इण्डियन इंस्टीट्यूट आफ़ ऐस्ट्रानौमिकल एण्ड संस्कृत रिसर्च

२२३९, गुरुद्वारा रोड, क़रौलबाग़, न्यू देहली-५

प्रकाशक—
इंडियन इंस्टीट्यूट ग्राफ़ ऐस्ट्रानौमिकल एण्ड संस्कृत रिसर्च
२२३६, गुरुद्वारा रोड, क़रौल बाग़,
नई दिल्ली-५ (भारत)

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भारत सरकार के शिक्षा मन्त्रालय द्वारा प्रदत्त अनुदान से प्रकाशित ।

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सम्पादक मण्डल—
श्री रामस्वरूप शर्मा सञ्चालक
प्रधान सम्पादक
डा० सत्यप्रकाश डी० एस-सी०
प्रस्तावना-लेखक
श्री मुकुन्दमिश्र ज्योतिषाचार्य
श्री विश्वनाथ झा ज्योतिषाचार्य
श्री दयाशंकर दीक्षित ज्योतिषाचार्य
श्री ओंदत्त शर्मा शास्त्री
एम. ए., एम. ओ. एल.

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प्रथम संस्करण
१९६६

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मूल्य रु० ८०.००

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मुद्रक :
पद्म श्री प्रकाशन एण्ड प्रिण्टर्स
१२ चमेलियन रोड,
दिल्ली ।

समर्पण :

श्रीयुत एस० के० पाटिल

यूनियन मिनिस्टर फ़ार रेल्वेज़

को

सादर समर्पित

Foreword

The Indian Institute of Astronomical & Sanskrit Research has done a very useful piece of work by publishing the Brāhma Sphuṭa Siddhānta. This is an original work on Astronomy written about twelve hundred years ago. Mainly devoting himself to Astronomy as was natural, the author, Brahma Gupta, has also given considerable space to such branches of Mathematics as in his opinion are particularly applicable to Astronomy. Brahma Gupta is not a mere theoriser. His work bears ample evidence of close observation of astronomical phenomena, though he did not have at his disposal any large and well equipped Vedhālaya or Observatory. He has had to find fault with some of his predecessors. The main reason for his criticism was as stated by him:

ब्रह्मोक्तं ग्रहगणितं महता कालेन यत् श्लथीभूतम् ।
अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन ॥

The creator Brāhma himself had given certain calculations in his book namely Brahma Siddhānta. But in the course of many years these calculations have been found to have bocome inaccurate. Of course, in referring to calculations, the author is referring to the bases of these calculations, the main data of astronomy. The excellent and fairly exhaustive introduction by Dr. Satya Parkash is of very great help in understending the book because it brings out clearly the various points on which Brahma Gupta has laid stress, particularly those on which he differs from other great astronomers.

A great controversy still rages between two schools of Indian astronomers which for want of better names may be called the schools of Arya Bhata and Brahma Gupta. Some years ago the Indian Institute of Astronomical & Sanskrit Research published the Vateshwar Siddhānta which is supposed to be associated with the Arya Bhata School. It is, therefore, in the fitness of things that it should now publish the present standard volume of the other school.

To my mind the Publication of such books is of great value from two points of view. It helps to remove the ignorance of average educated Indian of today about the achievements of his ancestors. In the field of two important branches of science, Mathematics and Astronomy, it is really surprising how those ancient astronomers could reach such heigts of accuracy with the help of instruments which seem to be laughably crude compared to those that modern astronomers have at their disposal. At the same time a study of such literature is a very salutary corrective

to the vanity of those who feel that in astronomy as in certain other subjects the last word was said by those writers who have written in Sanskrit. We learn how far behind we are in certain very important directions in the field of knowledge.

It is interesting by the way to find that the author of this great work was a Vaishya. This shows how diffused knowledge even of the most abstract subjects was in those days and how Scholarship was honoured irrespective of caste. Not one the critics of Brahma Gupta has taunted him on the ground of his not being a Brahmana.

Sampurnanand
Governor-Rajasthan

Raj Bhavan,
Jaipur,
Dated May 4, 1966.

—:o:—

Observations

of

Dr. K. M. Munshi

President of the Reception Committee

The Author Shri Ram Swaroop Sharma has given to the world of scholars an excellent and valuable treatise on the famous Astronomer Brahma-Gupta, son of Jiṣṇugupta, born in 589 A. D. in Bhillamala or Srimala now in Southern Marwad close to the northern frontier of modern Gujarat. The work is divided into 13 chapters and at the end of each, the learned author has given reference to other works and treatises for further study as also in support of his various conclusions. He has described Astronomy in Ancient India in the light of the knowledge of the subject available in different countries in his time.

After giving personal details of Brahma-gupta, the author starts on a critical study of the works of that Astronomer-particularly his *Brahma-sphuta-siddhānta* and *Khandana-Khādya*. The author has also discussed the Indian Luni-solar Astronomy, the Greek and Hindu methods in spherical Astronomy and the Epicyclic theory of ancient Indians. Discussing in detail the contribution of Brahma Gupta in Arithmetic, Algebra, in Astronomy and the Astronomical instruments that he used, the author has brought out the various highlights of his work and achievements in comparison with those of his predecessors, successors and contemporaries in other countries.

The author deserves to be congratulated for this scholarly contribution on the subject of Ancient Indian mathematics and Astronomy.

—*K.M. Munshi*

Bhartiya Vidya Bhawan
Bombay

Publisher's Note

It is with pride and pleasure that the Indian Institute of Astronomical & Sanskrit Research brings out its second monumental work 'Brāhma Sphuṭa Siddhānta'. The Institute, set up on the 23rd November, 1957, with the object of promoting research into ancient Indian manuscripts on Astronomy and allied Sciences, started its programme of publication with the preparation of a critical edition of Vateshwara Siddhānta running into more than 700 pages. It was far back in early forties that the idea of reviving the treasures of knowledge hidden in ancient manuscripts came to my mind. In 1945 I could succeed in editing and publishing 'Trailokya Prakāśa' of Acharya Hema Prabha Sūri.

Ālbruni's Travel Accounts of India contain a reference to Vateshwara Siddhānta and this fact was responsible for prompting me to arrange publication of Vateshwar Siddhanta. It was rather difficult to search out this manuscript and the clue given by Mahamahopadhyaya Sudhākar Dwivedi (a great Mathematician and Astronomer of 19th century) that the manuscript was available in Gwalior did not lead me to any results. I kept my search on and found a copy of this text in the collection of manuscripts inherited by a Brahman widow of Gujranwala District in west Pakistan. The same style of copy was later seen by me in the Panjab University Library at Lahore.

Vateshwarāchārya, the great writer of Vateshwara Siddhānta, has criticised Brāhma Sphuṭa Siddhānta of Brahma Gupta, in his work. This naturally aroused my curiosity to procure and publish Brahma Sphuṭa Siddhānta so as to provide right perspective to the students of ancient Indian Scientific literature. Moreover, in one of my discussions with the late Dr. K. S. Krishnan, Director, National Physical Laboratories, New Delhi, he referred to Dr. Colebrook (a German Writer) as having translated into English two chapters of 'Brāhma Sphuṭa Siddhānta', namely, Vyakta (Arithmetic) and Ayakta (Algebra). The late Dr. Krishnan showed keen interest in this manuscript and encouraged me in taking up preparation of a critical edition of this text. The Institute is grateful to the Govt. of India (Department of cultural Affairs) for meeting part of the expenditure on this publication and thereby enabling us to complete our task.

I shall be failing in my duty if I do not mention the great and invaluable contribution made for the success of the Institute by its founder President the late Shri Brijlal Nehru. It was under his able guidance that the Institute started functioning and its various programmes were finalised. His passing away has been a big and irreparable loss to us The Institute will keep his memories always alive by following his ideals and by executing with zeal the programmes inspired by him.

I must take this opportunity to express my heartfelt gratitudes to Shri B. B. Varma, Member Parliament, who has never shirked in shouldering the responsibilities of managing the affairs of the Institute first as a member of its Executive Council and now as its President. I am also thankful to Dewan Hari Krishan Das, Chairman of the Executive Council and Shri F.C. Bedi Treasurer of the Institute for their ungrudging support to the cause of the Institute.

My thanks are also due to Dr. Sampurnanand, Governor Rajasthan, who has blessed the Institute by inaugurating it and has now been kind to write a foreword for the present book. I am also indebted to Dr. Satya Prakash, Head of the Deptt. of Chemistry, Allahabad University for his having spared time to write an introduction in English for this publication. He has always been cheerfully allowing us to draw on his rich experience and wealth of knowledge. I am also grateful to Pt. Mukund Mishra, Pt. Vishwa Nath Jha, Shri Daya Shankar Dixit and Pt. Om Datt Sharma, the learned scholars who helped me in preparing this work.

The book has been published in four volumes. Volume I includes introduction in English by Dr. Satya Prakash followed by the text as given in the copy of the manuscript obtained from the Bhandarkar Research Institute, Poona, with footnotes to collate the various versions found in the copies of the manuscripts procured from the Royal Asiatic Society, Bombay, the Oriental Research Institute, Baroda and the Vishweshwaranand Vedic Research Institute, Hoshiarpur. The volume also contains a Sanskrit Bhumika from the Chief Editor and an Index of Shlokas. Volume II comprises of the first nine chapters of Brāhma Sphuṭa Siddhānta containing only those readings which we have considered as correct. It also includes Vāsanā commentary of Pṛthūdaka Swāmi and Vigyān Bhashya in Sanskrit with Hindi translation. Volume III includes chapters 10 to 16. This volume also contains Nutan Tilak commentary of Sudhakar Dwivedi and Vigyan Bhashya in Sanskrit with Hindi translation. Volume IV comprises of chapters 17 to 24 and also an Index of Shlokas contained in Volumes II. III and IV. It also includes an appendix on Dhayāna Grhaoṛadeshādadhyāya. Another appendix in this volume contains Vāsanā commentary on Golādhyāya.

The Institute has planned to add to its list of publications, shortly, Samrāṭ Siddhānta (3000 pages and already in press). Bṛhad Yavan Jātaka (2000 pages) and Panch Siddhāntikā (1600 pages).

The Indian Institute of Astronomical & Sanskrit Research considers it a proud priviledge to dedicate Brāhma Sphuṭa Sidhānta to Shri S. K. Patil, Union Minister for Railways. I am highly grateful to him for his having consented to this dedication. I am also grateful to Shri K. M. Munshi and Shri Wadilal Chaturbhuj Gandhi for their kindly agreeing to my request to be President and Chairman respectively of the Reception Committee. My heart felt thanks are also due to Shri Kanti Lal H. Shah. Hony. Secy. of the Organising Committee and to all the members of the organising and the Reception Committees for their help and cooperation in my work. I also owe a debt of grati-

tude to the Patrons of the Institute : His Majesty the King of Nepal, Abhinaya Samrat. Shri Prithvi Raj Kapoor, Shri Dhairyasinh, R. Morarji, Chairman Dharamsi Morarji & Co., Bombay, Shri Pranlal Bhogilal, Patel Bombay for their invaluable help. I am also grateful to the life members of the Institute : H.H. Maharaja Manabendra Shah of Tehri Garhwal, Yuvraj P.C Dev, Shri B.N. Bhaskar, Shri R.K. Batra, Shri Sada Jivatlal Chandulal, Shri Shiv Kumar Bhuvalka, Shri Jamna Das H. Moorjani, Shri Shantilal K. Somaiya, Shri Kisonlal M. Diwanji, Solicitor, Shri N. K. Jalan, Shri D. R. Nayar, Shri Vadilal C. Gandhi, Shri Devi Prasad Khandelval, Shri Ram Prasad Khandelval, Shri B. K. Jalan, Shri Amir Chand T. Gupta, Shri Laxman Vaman Apte, Smt. Padma Koregaonkar, Shri Yodh Raj Bhalla for their support to the Institute.

I must make a special mention here of shri A. N. Jha, Chief Commissioner, Delhi, who has greatly encouraged me in my task of publishing old manuscripts. His help in solving the various problems faced by me, has been invaluable. I am highly grateful to him for his support in my cause. I am also grateful to H. H. Maharaja Manabedra Shah of Tehri Garhwal, Seth Sadajivat Lal, Smti. Padma Koregaonkar, Lala Yodh Raj Bhalla, Shri F.A Fazalbhai, Shri Morar J. Vaidya, Shri N. J. Aggarwal, Shri P. S. Naulakha, Shri R. L. Maheshwari, Shri D. N. Bhattacharjee, Shri P. A. Narialwala, Shri P. M. Aggrawal, Shri Shiv Kumar Bhuvalka, Shri Navin Bhai Khandwala and Smti. Nirmala Gomte, Lala Jagan Nath Ji, Shri L.S. Aggarwal, Shri B.N. Saxena, Shri R.B. Shah, Shri L.O. Joshi, Shri T.S. Krishnamurti, Shri R. S. Chitkara, Dr. Ram Karan Sharma, Shri V.P. Agnihotri, Shri K.L. Handa and Shri K.G. Somayya for their help and advice at various occasions.

Ram Swarup Sharma

Bombay
17-5-1966.

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विषयानुक्रमणिका

—:o:—

भूमिका

ब्रह्मगुप्तकृतो ब्राह्मस्फुटसिद्धान्तः

श्रीचापवंशतिलके श्रीव्याघ्रमुखे नृपे शकनृपाणाम् ।
पञ्चाशत्संयुक्तैर्वर्षशतैः पञ्चभिरतीतैः ॥
ब्राह्मः स्फुटसिद्धान्तः सज्जनगणितज्ञगोलवित्प्रीत्यै ।
त्रिंशद्वर्षेण कृतो जिष्णुसुतब्रह्मगुप्तेन ॥

इति ब्राह्मस्फुटसिद्धान्तीयसंज्ञाध्याये आचार्योक्त्या ५२० शाकवर्षे-आचार्यस्य (ब्रह्मगुप्तस्य) जन्म समयस्ततः परं त्रिंशति वर्षेषु गतेषु तेन ब्राह्मस्फुट-सिद्धान्तसंज्ञको ज्यौतिषसिद्धान्तग्रन्थो विरचितः[1]। गुर्जरदेशमध्ये भिनमाल नाम ग्राम एवास्य जन्मस्थानं बहूनां पाश्चात्यानां गवेषणया सिध्यति। गुर्जरदेशीय-ज्योतिर्विदां मुखकथातोऽपि भिल्लमालकोऽधुना भिनमालनाम्ना प्रसिद्धो ग्राम एवाऽऽचार्यस्य जन्मस्थानं सिध्यति। गुर्जरदेशोत्तरसीमायां मालव (माड़वार) देशतो दक्षिणस्यां दिशि आबूपर्वतलूणीनद्योर्मध्ये तत्पर्वताद्वायुकोणेऽयं भिनमाल-नामा ग्रामोऽधुना प्रसिद्धोऽस्ति।

विष्णुधर्मोत्तरपुराणान्तर्गतं ब्रह्मसिद्धान्तमागमीकृत्य ब्राह्मस्फुट सिद्धान्तो ब्रह्मगुप्तेन विरचितः। नलिकादिवेधद्वारेण दृग्गणितैक्यकारि—ग्रहादि साधन-कारणात्प्राचीनं ब्रह्मसिद्धान्तं संशोध्य नवीनं ब्राह्मस्फुटसिद्धान्तं रचितवान् ब्रह्मगुप्तः।

ब्रह्मोक्तं ग्रहगणितं महता कालेन यत् खिलीभूतम् ।
अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन ॥
संसाध्य स्पष्टतरं बीजं नलिकादियन्त्रेभ्यः ।
तत्संस्कृतग्रहेभ्यः कर्त्तव्यौ निर्णयादेशौ ॥

इत्याद्युक्त्या स्फुटं ज्ञायते। अस्य चतुर्वेदाचार्यपृथूदककृता तिलकसंज्ञिका टीका प्रसिद्धाऽऽसीत् साऽधुना सम्पूर्णा सम्प्रति नोपलभ्यते। 'कोलब्रूक' साहेब-महोदयैः सम्पूर्णा सा टीको (पृथूदक कृता) पलब्धा तद्बलेनास्य ग्रन्थस्य द्वादशाष्टा-दशाध्याययोर्व्यक्ताव्यक्तगणितसंज्ञयोराङ्गलभाषायामनुवादः १७३९ शाकवर्षे

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१. गुप्तपदान्ताद्वैश्यकुलोत्पन्नो रीवांनरेशस्य व्याघ्रभटेश्वरस्य प्रधानज्योतिषिक आसीदयमिति बहूनां मतमस्ति।

(१८१७ खीष्टाब्दे) कृत इत्युपलभ्यते। अत्र ब्राह्मस्फुटसिद्धान्तेऽष्टाधिक सहस्र-१००८मिता आर्याः सन्ति, तथा पूर्वार्धे १. मध्यगतिः। २. स्पष्टगतिः। ३. त्रिप्रश्नाध्यायः। ४. चन्द्रग्रहणाध्यायः। ५. सूर्यग्रहणाध्यायः। ६. उदयास्तमयाध्यायः। ७. चन्द्रशृङ्गोन्नत्यध्यायः। ८. चन्द्रच्छायाध्यायः। ९. ग्रहयुत्यध्यायः, १० भग्रहयुत्यध्यायः, इति दशाध्यायाः सन्ति। परार्धे च १. तन्त्रपरीक्षाध्यायः। २. गणिताध्यायः। ३. मध्यगत्युत्तराध्यायः। ४. स्फुटगत्युत्तराध्यायः। ५. त्रिप्रश्नोत्तरध्यायः। ६. ग्रहणोत्तराध्यायः। ७. छेद्यकाध्यायः। ८. शृङ्गोन्नत्युत्तराध्यायः। ९. कुट्टाकाराध्यायः। १०. छन्दश्चित्युत्तराध्यायः। ११. गोलाध्यायः। १२. यन्त्राध्यायः। १३. मानाध्यायः। १४. संज्ञाध्यायः। इति चतुर्दशाध्यायाः सन्ति, पूर्वार्धपरार्धाध्याययोर्योगेन चतुर्विंशतिरध्याया अत्र ग्रन्थे सन्ति। तेषु तन्त्रपरीक्षाध्यायो विचारार्हः। अत्र बहूनामाचार्याणां नामानि मतानि चाचार्येणोल्लिखितानि। यथा—

लाटात् सूर्यशशाङ्कौ मध्याविन्दूच्च चन्द्रपातौ च।
कुजबुध शीघ्रबृहस्पति सितशीघ्र शनैश्चरान् मध्यान् ॥

युगयातवर्षभगणान् वासिष्ठाद्विजयनन्दिकृतपादात्।
मन्दोच्चपरिधि-पात-स्पष्टीकरणाद्यमार्यभटात् ॥

श्रीषेणेन गृहीत्वा रक्षोच्चयरोमकः कृतः कन्था।
एतानेव गृहीत्वा वासिष्ठो विष्णुचन्द्रेण ॥

अनयोर्न कदाचिदपि ग्रहणादिषु भवति दृष्टिगणितैक्यम्।
यद्भवति तद्घुणाक्षरमतोऽस्फुटाभ्यां किमेताभ्याम् ॥

एभिः श्लोकैः श्रीषेणाचार्यकृतो रोमकसिद्धान्तः, विष्णुचन्द्रकृतश्च यो वासिष्ठसिद्धान्तस्तयोर्दूषणमाहेति टीकाकृतश्चतुर्वेदाचार्यस्य कथनमस्ति। पञ्च-सिद्धान्तिकायां श्रीषेण विष्णुचन्द्रयोरनुल्लेखात् वराहमिहिराचार्यानन्तरं ब्रह्म-गुप्ततः पूर्वमेतौ ज्यौतिषसिद्धान्तग्रन्थरचयितारावास्ताम् ४२७ शाकवर्षात् पश्चात् ५५० शाकवर्षात्पूर्वं तयोः (श्रीषेण विष्णुचन्द्रयोः) रोमकसिद्धान्तो वासिष्ठ-सिद्धान्तश्चातिगणितस्थौल्यमापन्नाविति स्वयं वेधद्वारा स्थिरीकृत्यैवाऽऽचार्येण (ब्रह्मगुप्तेन) प्रौढोक्त्या 'यद्भवति तद्घुणाक्षर'मित्यादि कथ्यते। अत्रार्यभटस्य सिद्धान्तः सर्वत्रैव दोषावह एवेति वदन्नप्याचार्यो (ब्रह्मगुप्तः) बहुधैव तदुक्तीरेव खण्डयितुं ग्रन्थमरचयत्। यथा भूभ्रमणं खण्डयति—

प्राणेनैति कलां भूर्यदि तर्हि कुतो व्रजेत् कमध्वानम्।
आवर्त्तनमुर्व्याश्चेन्न पतन्ति समुच्छ्रयाः कस्मात् ॥

पृथिव्याश्चलत्वं भगणानां स्थिरत्वं स्वीकृत्य—अहोरात्रासुभिः स्वाक्षोपरि पृथिव्या भ्रमणं मन्यते आर्यभटेनेति–आवर्त्तनमुर्व्याश्चेदित्याद्युक्तिः। अन्यत्रानेका अत्युक्तयो दुराग्रहवशात् कुत्रचिद्वाग्बलेन कथिता ब्रह्मगुप्तेन यथा—

स्वयमेव नाम यत्कृतमार्यभटेन स्फुटं स्वगणितस्य ।
सिद्धं तदस्फुटत्वं ग्रहणादीनां विसंवादात् ॥
जानात्येकमपि यतो नार्यभटो गणितकालगोलानाम् ।
न मया प्रोक्तानि ततः पृथक् पृथक् दूषणान्येषाम् ॥
आर्यभटदूषणानां संख्या वक्तुं न शक्यते यस्मात् ।
तस्मादयमुद्देशो बुद्धिमताऽन्यानि योज्यानि ॥

स्वयं ग्रहग्रहणादिवेधकर्त्ता ब्रह्मगुप्तः प्राचीनाचार्येभ्योऽनेकान् विशिष्टान् ग्रहादिसाधनविधीन् गणितसत्यासत्यपरीक्षार्थं वेधविधींश्च स्वग्रन्थे प्रौढोक्त्या प्रतिपादयति—

ज्ञातं कृत्वा मध्यं भूयोऽन्यदिने तदन्तरं भुक्तिः ।
त्रैराशिकेन भुक्त्या कल्पग्रहमण्डलानयनम् ॥
यदि भिन्नाः सिद्धान्ता भास्करसंक्रान्तयोऽपि भेदसमाः ।
स स्पष्टः पूर्वस्यां विषुवत्यर्कोदयो यस्य ॥

इत्यादिना वास्तवविचारासक्तः सर्वप्रथमं सर्वतो विशिष्टं विवेचनाबहुलं सिद्धान्तग्रन्थं ब्रह्मगुप्त एव रचितवानित्युपलब्धज्यौतिषसिद्धान्तग्रन्थेभ्यो ज्ञायते। 'कृती जयति जिष्णुजो गणकचक्रचूडामणि' रितिस्वसिद्धान्तशिरोमणेर्गणिताध्यायारम्भे भास्कराचार्येण ब्रह्मगुप्तमभिवन्द्य तत्परमपि बहुत्रस्थले ब्रह्मगुप्तमतोल्लेखं कुर्वताऽपि 'यथाऽत्रग्रन्थे ब्रह्मगुप्तस्वीकृतागमोऽङ्गीकृत' इत्युक्त्या तद्ग्रन्थानुसारी ग्रन्थो रचित इति प्रतीयते। ब्रह्मगुप्तेनायनचलनं नोपलब्धमिति ब्रह्मस्फुटसिद्धान्ततो ज्ञायते । अयनचलनोपलब्धिः प्रत्युत खण्डितेति दृश्यते यथा—

परमल्पामिथुनान्ते द्युरात्रिनाड्योऽर्कगतिवशाद्दतवः ।
नायनयुगमयनवशात् स्थिरमयनद्वितयमपि तस्मात् ॥

वराहमिहिरोऽयनचलनसम्बन्धे सन्दिहान आसीदिति 'नूनं कदाचिदासीद्येनोक्तं पूर्वशास्त्रेषु' इति तत्कथनेन ज्ञायते। तत्समयेऽश्विन्यादौ क्रान्तिपात आसीदित्यश्विन्यादि नक्षत्रगणना प्रवृत्ता सैव ब्रह्मगुप्तात्परमद्यावधि प्रचलति।

पञ्चषष्टया वर्षैः क्रान्तिपातः प्राय एकमंशं पश्चिमदिश्यपसरति तज्ज्ञानं स्वल्पकालेनासम्भव इवेति वेधविज्ञेनापि ब्रह्मगुप्तेनायनचलनं नोपलब्धमिति । आर्यभटविरोधी भूत्वापि ब्रह्मगुप्तो ब्राह्मस्फुटसिद्धान्तरचनानन्तरं सप्तत्रिंशत्तमे वर्षे खण्डखाद्यकं नामकरणग्रन्थं रचितवान् यथा तत्प्रारम्भे—

प्रणिपत्य महादेवं जगदुत्पत्तिस्थितिप्रलयहेतुम् ।
वक्ष्यामि खण्डखाद्यकमाचार्यार्यभटतुल्यफलम् ॥

प्रायेणार्यभटेन व्यवहारः प्रतिदिनं यतोऽशक्यः ।
उद्वाहजातकादिषु तत्समफललघुतरोक्तिरतः ॥

इति तदुक्तग्रन्थपर्यालोचनया ज्ञायते यत्सर्वत्र व्यवहारकृतां मानवानां मध्ये प्रचरितार्यभटमत निराकरणमतीव कठिनमासीदिति—'आर्यभटमतानुसारिव्यवहरतां तात्कालिकजनानामुपकारायैव व्यावहारिकः करणग्रन्थः खण्डखाद्यकनामको रचितो ब्रह्मगुप्तेन । यथोपलब्धेषु प्राचीनज्यौतिषसिद्धान्तग्रन्थेषु ब्राह्मस्फुटसिद्धान्त आदर्शरूपो ग्रन्थस्तथैव सर्वेषां करणग्रन्थानामादर्शरूपमादिमं वा इतस्त्रयोदशशतवर्षैः प्राचीनं खण्डखाद्यकं करणम् । अथ 'ब्रह्माह्वयश्रीधरपद्मनाभबीजानि यस्मादति विस्तृतानि' इति बीजगणिते भास्करोक्त्या ज्ञायते यद्ब्रह्मगुप्तस्य विपुलो बीजगणित ग्रन्थ आसीत्परमयं ग्रन्थः कुत्रापि नोपलभ्यते न वा श्रूयते । ब्रह्मगुप्त एव सर्वापेक्षया श्रीपतेरादर्शभूतः । ब्राह्मस्फुटसिद्धान्तसिद्धान्तशेखरयोः पर्यालोचनया ज्ञायते यद् ब्रह्मगुप्तोक्ताः संक्षिप्ता बहुलार्थयुक्ता आर्या एव बृहदाकारैश्छन्दोभिरनूदिताः श्रीपतिना । वस्तुतो ब्रह्मगुप्तोक्तं ग्रहगणितं सूक्ष्मं ज्ञात्वा सत्यमित्र तदेव स्वीकुर्वन् श्रीपतिस्तदुक्तिवैषम्यं स्वसुन्दररचनाभिरपहरन् सुगमतरं ग्रन्थांतरं (सिद्धान्त शेखरं) चकार, नात्र केषामपि विप्रतिपत्तिः । ग्रन्थरचनासम्बन्धे श्रीपतेर्विशेषतो लल्लाचार्य एवादर्शः । ये केचन विषया ब्रह्मगुप्तेन न कथिता अथ लल्लेन कथितास्तान् सर्वानेव नियतमेव श्रीपतिः श्लोकान्तरेण तथैव कथितवान् । वस्तुतो द्वयोर्ग्रन्थयोः (ब्राह्मस्फुट सिद्धान्तशिष्यधीवृद्धिदयोः) परिशीलनं कृत्वा श्रीपतिना सिद्धान्तशेखरो रचितः । ब्राह्मस्फुट सिद्धान्ते येषामाचार्याणां नामानि समागतानि सन्ति तेषां सम्बन्धे किञ्चिद्विविच्यते । सर्वेषां सिद्धान्तानामादिमः सर्वेभ्यः प्राचीनो वा ब्रह्मसिद्धान्त एव, स एव कैश्चित् पितामहसिद्धान्तनाम्नाप्युच्यते । पञ्चसिद्धान्तिकायां वराहमिहिरेण द्वादशोऽध्याय आर्यापञ्चात्मकः पैतामहसिद्धान्तः कथितो यथा—

रविशशिनोः पञ्चयुगं वर्षाणि पितामहोपदिष्टानि ।
अधिमासस्त्रिंशद्भिर्मासैरवमस्त्रिषष्ट्याऽह्नाम् ॥

द्व्यूनं शकेन्द्रकालं पञ्चभिरुद्धृत्य शेषवर्षाणाम् ।
द्विगुणं माघसिताद्यं कुर्याद् द्युगणं तदन्ह्युदयात् ॥२॥
सैक षष्ट्यंशे गणे तिथिर्भमार्कं नवाहतेऽक्ष्यर्कैः ।
दिग्रसभागैः सप्तभिरूनं शशिभं धनिष्ठाद्यम् ॥३॥
प्रागर्धे पर्व यदा तदोत्तराऽतोऽन्यथा तिथिः पूर्वा ।
अर्कघ्ने व्यतिपाता द्युगणे पञ्चाम्बरहुताशैः ॥४॥
द्व्यग्निनगेषूत्तरतः स्वमितमेष्य दिनमग्नि याम्यायनस्य ।
द्विघ्नं शशिरसभक्तं द्वादशहीनं दिवसमानम् ॥५॥

एतदनुसारेणैकस्मिन् युगे सौरवर्षाणि=५, सौरमासाः=५×१२=६० । अधिमासौ=२ । चान्द्रमासाः=६२ एते त्रिंशद्गुणितास्तिथयः=१८६०, अवमानि=३०, एभी रहितास्तिथयोऽहर्गणः=१८३० इति ॥

पञ्च सिद्धान्तिकायां 'पौलिश सिद्धान्तः' इति नाम्ना एकोऽध्यायो वर्त्तते, ब्राह्मस्फुट सिद्धान्तटीकायां पृथूदकेन बहून्येव पौलिशसिद्धान्तवचनानि प्रमाणत्वेनोद्धृतानि सन्ति । अस्य सिद्धान्तरचयितुः सम्बन्धे बहूनि मतान्तराणि सन्ति । वराहोक्तपौलिशसिद्धान्ते यवनपुरात् उज्जयिन्या वाराणस्याश्च देशान्तरमुल्लिखितमस्ति । यथा —

यवनाच्चरजा नाड्यः सप्तावन्त्यां त्रिभागसंमिश्राः ।
वाराणस्यां त्रिकृतिः साधनमन्यत्र वक्ष्यामि ॥

शाकल्यसंहितोक्त ब्रह्मसिद्धान्ते पुलिशसिद्धान्तोल्लेखो वर्त्तते । ब्राह्मस्फुटसिद्धान्तटीकायां पृथूदकेन 'देशान्तर रेखा च पौलिशे पठ्यते' इत्युक्तम् । तथा च पुलिशाचार्यः—

उज्जयिनी रोहीतककुरुयमुनाहिमनिवासमेरूणाम् ।
देशान्तरं न कार्यं तल्लेखामध्यसंस्थदेशेषु ॥'

इत्यादि विचारेण पौलिशसिद्धान्तः सर्वमान्य आसीदिति प्रतिभाति । परमयं सिद्धान्तः साम्प्रतं नोपलभ्यते इति ।

सूर्य सिद्धान्त एव प्राचीनतमः सर्वप्रथमः सिद्धान्तग्रन्थ इति बहूनां विदुषां मतम् ।

'केचित्प्रत्यक्षसूर्याच्च भिन्नोऽयमिति यद्बलात् ।
वदन्ति मूढवादस्याप्रामाण्यात्तदसद्ध्रुवम् ॥'

इति कमलाकरोक्तया स्वयं भगवान् सूर्य एवास्य रचयिता। आश्चर्य्यस्य विषयोऽयमस्ति यदत्र (सूर्यसिद्धान्ते) यनांशानयनम्।

'त्रिंशत्कृत्यो युगे भानां चक्रं प्राक् परिलम्बते।
तद्गुणाद्भूदिनैर्भक्ताद् द्युगणाद्यदवाप्यते॥'
'तद्दोस्त्रिघ्ना दशाप्तांशा विज्ञेया अयनाभिधाः।
तत्संस्कृताद् ग्रहात् क्रान्तिच्छाया चरदलादिकम्॥'

इत्यनेन कृतमस्ति। परं ब्राह्मस्फुटसिद्धान्तनिर्मात्रा ब्रह्मगुप्तेन तस्य (अयनांशस्य) चर्चाऽपि न कृता। कथं ब्रह्मगुप्तेन तच्चर्चा न कृतेति न ज्ञायते। सूर्य सिद्धान्तस्योदयास्ताधिकारे 'अभिजिद् ब्रह्महृदयं स्वातीवैष्णव वासवाः' इत्यादिना सदोदित नक्षत्राणि भगवता सूर्येण कथितानि सन्ति, अस्य श्लोकस्य सुधावर्षिणी टीकायां 'देशज्ञानं विना सदोदित नक्षत्राणां ज्ञानं न भवति निरक्षे च सौम्यध्रुवोऽप्यदृश्योऽतः केनचिद्गोलानभिज्ञेनायं श्लोकः प्रक्षिप्त, इति यल्लिखितमस्ति तत्समीचीनं नास्ति। पाताधिकारे पातस्थितिकालस्य फलं—

आद्यन्तकालयोर्मध्यः कालो ज्ञेयोऽतिदारुणः।
प्रज्वलज्ज्वलनाकारः सर्वकर्मसु गर्हितः॥
एकायनगतं यावदर्केन्द्वोर्मण्डलान्तरम्।
सम्भवस्तावदेवास्य सर्वकर्मविनाशकृत्॥
स्नानदानजपश्राद्धव्रतहोमादिकर्मभिः।
प्राप्यते सुमहच्छ्रेयस्तत्कालज्ञानतस्तथा॥

इत्यनेन पातस्थितिकालः सर्वकर्मविनाशकृदुक्तः। पातकाले स्नानदान-जपश्राद्धव्रतहोमादिकर्मभिर्महत्कल्याणं प्राप्यते लोकैरिति। तथा च—

रवीन्द्वोस्तुल्यता क्रान्त्योर्विषुवत्सन्निधौ यदा।
द्विर्भवेद्धि तदा पातः स्यादभावो विपर्ययात्॥

इत्यनेनापूर्वविषयः कथितोऽर्थाद्रविगोलसन्धिसमीपे यदा रविचन्द्रयोः क्रान्तिसाम्यं भवेत्तदाऽल्पेनैव कालेन द्विवारः पातः स्यात्। यदा रव्ययनसन्धि-समीपे क्रान्तिसाम्याभावस्तदा बहुकालपर्यन्तं क्रान्ति साम्याभावः स्यादिति।

ब्राह्मस्फुटसिद्धान्तेऽपि पातस्थितिकालफलं सूर्यसिद्धान्तोक्तवत्कथितम्। सिद्धान्तशेखरे कियत्कालपर्यन्तं पातफलमिति 'भानोर्बिम्बं तुहिनकिरणापक्रमे-णैकमार्गे यावत्तावन्मुनिभिरुदितसंभवस्तत्फलस्य। तस्याभावे भवति नियतं

तत्फलस्याप्यभावो यात्रोद्वाहादिषु पुनरिह द्युत्रयं नैव दुष्टम् ॥' अनेन कथितम्, अर्थात्सूर्यविम्बं तुहिनकिरणापक्रमेण (चन्द्रस्य स्पष्टक्रान्त्या सह) यावत्काल-पर्यन्तमेकमार्गे (एकस्मिन्नहोरात्रवृत्तेऽर्थाद्यावत् क्रान्त्योर्विवरं मानैक्यार्धादल्पं भवति यथा बिम्बैकदेशजक्रान्त्योः साम्यं भवतीत्यर्थः ।) तावत् मुनिभिः फलादेश-कृद्भिः पातसंजातफलस्य संभवः कथितः । तस्य सूर्यस्य चन्द्रस्य स्पष्टक्रान्त्या सहैकमार्गावस्थानाभावे तत्फलस्याप्यभावो भवति । इह पुनः पातस्थितिकाले यात्रोद्वाहादिषु मङ्गलकार्येषु दिनत्रयं दुष्टं नैव । केषुचित्फलग्रन्थेषु व्यतीपात-वैधृतयोः सतोस्तद्दिनं तत्पूर्वदिनमपरदिनं चेति दिनत्रयं शुभकार्ये निषिद्धमिति कैश्चिदुक्तं तत्परिहारार्थमाह—द्युत्रयं नैव दुष्टम् । सूर्यसिद्धान्तादिषु पातकाल एव शुभकार्येषु दोषभाक् गते पातकाले च दोषो न भवतीति । प्रसङ्गादत्र सिद्धान्तशेखरवचनोल्लेखः कृतः । यतः श्रीपतिराचार्या(ब्रह्मगुप्तात्) दर्वाचीनोऽस्ति । ब्राह्मस्फुट सिद्धान्ते तन्नामोल्लेखो नास्ति ।

भारतीयानां ज्योतिर्विदां मध्ये आर्यभट एव सर्वप्रथमं दिनरात्र्योः कारण-स्वरूपं पृथिव्या आवर्त्तनं कथयति । यथा गीतिकापादस्य प्रथमश्लोके एकस्मिन् महायुगे ४३२०००० भूमेर्भगणाः १५८२२३७५०० एतावन्तो भवन्तीति प्रथमं कथयित्वा दृष्टान्तद्वारेण भूभ्रमणं—

अनुलोमगतिर्नौस्थः पश्यत्यचलं विलोमगं यद्वत् ।
अचलानि भानि तद्वत् समपश्चिमगानि लङ्कायाम् ॥

अनेन दृढीकरोति । परमत्र विचित्रमेतदवलोक्यते यदार्यभटीय टीका-कारेण परमेश्वरेणैतत्-श्लोकस्यावतरणं 'भूमेः प्राग्गमनं नक्षत्राणां गत्यभावञ्चे-च्छन्ति केचित्तन्मिथ्याज्ञानवशादुत्पन्नां प्रत्यग्गमन प्रतीतिमङ्गीकृत्य भूमेः प्राग्ग-तिरभिधीयते । परमार्थतस्तु स्थिरैवभूमिः' इत्युक्तम् । स्वयमप्यार्यभटः—

उदयास्तमय निमित्तं नित्यं प्रवहेण वायुना क्षिप्तः ।
लङ्कासमपश्चिमगो भपञ्जरः सग्रहो भ्रमति ॥

इत्यनेन भूभ्रमणमस्वीकरोतीति दृश्यन्ते । आर्यभटस्य मनसि निश्चयो नासीद्यत् पृथिवी चलति-नवा चलति । ब्रह्मगुप्तेनैकमपूर्वं वस्तु 'नतकर्म' प्रति-पादितम् । मन्दफल-शीघ्रफल-भुजान्तरादि संस्कारेण यो हि स्पष्टग्रहः समा-गच्छति स स्वगोलीयः (ग्रहगोलीयः) स ग्रहोऽस्माकं यत्र प्रत्यक्षीभूतो भवति स एवास्माकं स्पष्टग्रहो भवितुमर्हति । स्वगोलीयस्पष्टग्रहे यावता संस्कारेणास्माकं स्पष्टग्रहो भवति तस्यैव संस्कारस्य नाम 'नतकर्म' ब्रह्मगुप्ततः केऽपि प्राचीना आचार्या एतस्य (नतकर्मणः) नामोल्लेखं न कृतवन्तः । भास्कराचार्येण सिद्धान्त-

शिरोमणेर्गणिताध्यायस्य स्पष्टाधिकारे-एतस्याऽनयन प्रकारोऽभिहितः। 'मुहुः स्फुटातो ग्रहणे रवीन्द्वोस्तिथिस्त्विदं जिष्णुसुतो जगाद' इति भास्करोक्तेर्ज्ञायते यदेतस्याविष्कर्त्ता ब्रह्मगुप्त एवास्ति। भास्कराचार्येण भोग्यखण्डस्पष्टीकरणं यदभिहितं तन्मूलमपि ब्राह्मस्फुटसिद्धान्तस्य ध्यानग्रहोपदेशाध्याये ब्रह्मगुप्तोक्त-मेव, न ह्यन्यैराचार्यैस्तत्सम्बन्धे किमपि लिखितम्। कमलाकरेण तु सिद्धान्त-तत्वविवेके भास्करोक्तभोग्यखण्डस्पष्टीकरणस्य खण्डनमेव कृतम्। वस्तुतः कमलाकरोक्तं खण्डनं न समीचीनम्। ब्राह्मस्फुटसिद्धान्ते त्रिप्रश्नाधिकारे दिक्साधने 'पूर्वापरयोर्बिन्दू तुल्यच्छायाग्रयोर्दिगपराद्यः। पूर्वान्यः क्रान्तिवशात् तन्मध्याच्छङ्कुतल मितरे' इत्यत्र क्रान्तिवशाद्दिक्साधने कथं भेद उत्पद्यते तदर्थं चतुर्वेदाचार्येण कर्णवृत्ताग्रान्तरं यत्साधितं तदेव 'छायानिर्गमनप्रवेशसमयार्क-क्रान्तिजीवान्तरमि' त्याद्युक्त्या श्रीपतिना, तदनु 'तत्कालापम जीवयोस्तुविवराद्वि' त्यादिना भास्करेण च गृहीतम्। मन्दफलानयने वस्तुतो मन्दकर्णानुपातेनैव मन्दफलं सिध्यति। यद्यप्यत्र भास्करेण स्वमतं न प्रतिपादितं तथापि चन्द्रग्रहणे स्फुटरविचन्द्रकर्णसाधने 'मन्दश्रुतिर्द्राक्श्रुतिवत् प्रसाध्या' इत्यादिना ब्रह्मगुप्त-स्यैव मतं स्वीकृतमित्यपि ब्रह्मगुप्तोक्तेर्वैलक्षण्यमस्ति। लल्लाचार्येण वलनदृक्क-र्मणोरानयनमुत्क्रमज्ययाकृतमिति ब्रह्मगुप्तोक्तौ 'अत्र ज्याशब्देनोत्क्रमज्या ग्राह्येति' चतुर्वेदाचार्यव्याख्यानमेव लक्ष्यीकृत्य भास्करेण 'ब्रह्मगुप्तकृतिरत्र-सुन्दरी साऽन्यथा तदनुगैर्विचार्यते' इत्युक्तम्।

'युगमन्वन्तरकल्पाः कालपरिच्छेदकाः स्मृतावुक्ताः।
यस्मान्न रोमके ते स्मृतिवाह्यो रोमकस्तस्मात्॥'

(ब्राह्मस्फुट सिद्धान्त अध्याय १)

इति ब्रह्मगुप्तोक्त्या 'रोमक' इति नाम्ना चायं कस्यचित्पाश्चात्यज्यो-तिर्विदो मूलमादाय रोमकसिद्धान्तो रचित इति स्फुटं भवति। प्राचीनाचार्याणां मध्ये केवलं ब्रह्मगुप्त एव रोमकमतं खण्डयति। वराहमिहिरस्तु रोमक सिद्धान्तमतेनाहर्गणादीनां बहूनामेव सिद्धान्तोक्तविषयाणां साधनं स्वीकरोति। ब्रह्मगुप्तः—

ब्रह्मोक्तं ग्रहगणितं महता कालेन यत् खिलीभूतम्।
अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन॥

इत्युक्त्या ब्रह्मसिद्धान्तमेव संस्कृतवानिति स्फुटमेव। तदेतेषां मूलरूप एको ब्रह्मसिद्धान्तोऽतिप्राचीन आसीदिति सिद्धयति। ब्रह्मगुप्तस्तु—

'येऽज्ञानपटलरुद्धदृशोऽन्यं ब्राह्माद्वदन्ति सिद्धान्तम्।
तेषां युगादिभेदे ये दोषास्तान् प्रवक्ष्यामि॥'

इत्युक्त्याऽन्यान् सर्वान् सिद्धान्तान्निन्दन्ति । ब्राह्मस्फुटसिद्धान्ते बहुषु स्थलेषु स्थौल्यं त्वस्त्येव तथापि बहवो विषया अत्र निवेशिताः सन्ति, तस्मात्सर्वश्रेष्ठो ब्राह्मस्फुटसिद्धान्तोऽस्तीतिकथने न काचिद्विप्रतिपत्तिः प्रतिभाति । अत्रैकोऽध्यायो 'छन्दश्चित्युत्तराध्यायः' अस्ति, यत्र लिखितानां श्लोकानां व्याख्योपपत्तिश्चाद्यावधि केनापि न कृता तेषु तादृशं काठिन्यमस्ति यदर्थो न मनसि समागच्छति, उपपत्तेश्च कथैव का ?, प्रश्नाध्यायो यादृशोऽत्र ग्रन्थेऽस्ति न तादृशोऽन्येषु सिद्धान्तग्रन्थेषु । अत्र ग्रन्थे मध्यगत्यादीनां पञ्चाध्यायानां प्रश्नाः सोत्तराः पृथक् पृथक् लिखिताः सन्ति । येषामभ्यासेन पाठका अतीव सिद्धान्तग्रन्थे निपुणा भवितुमर्हन्ति । सिद्धान्तशिरोमणेर्भूमिकायां 'जीवासाधनं विनैव यद्भुजज्यानयनं कृतवान् श्रीपतिस्तत्त्वपूर्वमेव स्यात् । यथा तत्प्रकारो विदां विनोदाय प्रदर्श्यते —

दोः कोटिभागरहिताभिहताः खनागचन्द्रास्तदीयचरणेन शरार्कदिग्भिः ।
ते व्यासखण्डगुणिता विहृताः फलं तु ज्याभिर्विनापि भवतो भुजकोटिजीवे ॥

इति केनापि लिखितमस्ति तन्नैव युक्तियुक्तं यतो ज्याभिर्विना भुजकोटिज्ययोरानयनं ज्यातश्चापानयनं च सर्वप्रथमं ब्रह्मगुप्तेनैव कृतम् यथा तदुक्तप्रकारः —

भुजकोट्यंशोनगुणा भार्धांशास्तच्चतुर्थभागोनैः ।
पञ्चद्वीन्दुखचन्द्रैर्विभाजिता व्यासदलगुणिता ॥
तज्ज्ये परमफलज्या सङ्गुणिता तत्फले विना ज्याभिः ।
इष्टोच्चनीचवृत्तव्यासार्धं परमफलजीवा ॥'[1]

इष्टज्यातश्चापानयनञ्च

इष्टज्यासङ्गुणिताः पञ्चकयमलैकशून्यचन्द्रमसः ।
इष्टज्यापादयुतव्यासार्धं विभाजिता लब्धम् ॥
नवतिकृतेः प्रोह्यपदं नवतेः संशोध्य शेषभागकलाः ।
एवं धनुरिष्टाया भवति ज्याया विना ज्याभिः ॥

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१. चिरादेव प्रकारोऽयं श्रीपत्युक्तोऽस्तीति ज्योतिर्विदां मध्ये प्रसिद्धोऽस्ति । तथैव ज्यातश्चापानयनमपि । एतदवलम्ब्यैव ग्रहलाघवे करणग्रन्थे गणेशदैवज्ञेन बहवः प्रकारा विलिखिताः ।

एतदनुरूप एव बटेश्वरसिद्धान्ते बटेश्वरेण स्वीयप्रकारोऽभिहितः । सिद्धान्तशेखरे सर्वत्र श्रीपतेः स्वकीयः प्रकारोऽल्पीयानेवास्ति, ब्रह्मगुप्तोक्तप्रकारा एव छन्दोऽन्तरेण लिखिताः सन्ति[1] वराहोक्त पञ्चसिद्धान्तिकायां त्रयोदशभिरार्याभिरुक्तो वासिष्ठसिद्धान्तः पैतामहसिद्धान्तश्च वराहोक्त्यैव दूरभ्रष्टाविति तत्रापि ब्रह्मसिद्धान्तापेक्षया यत्किञ्चित् वासिष्ठसिद्धान्तः सूक्ष्मताभिधायि । तन्त्रपरीक्षाध्याये—

लाटात् सूर्यशशाङ्कौ मध्याविन्दूच्च चन्द्रपातौ च ।
कुजबुधशीघ्रबृहस्पति सितशीघ्रशनैश्चरान् मध्यान् ॥
युगजातवर्ष भगणान् वासिष्ठाद्विजयनन्दिकृत पादात् ।
मन्दोच्चपरिधिपातस्पष्टीकरणाद्यमार्यभटात् ॥
श्रीषेणेन गृहीत्वा रत्नोच्चयरोमकः कृतः पन्थाः ।
एतानेव गृहीत्वा वसिष्ठो विष्णुचन्द्रेण ॥

इति ब्रह्मगुप्तोक्त्या वसिष्ठसिद्धान्तरचयिता विष्णुचन्द्रनामकः कश्चिदासीत् । सम्भवतोऽयं विष्णुचन्द्रः प्राचीनं वसिष्ठसिद्धान्तं संस्कृतवानिति 'एतानेव गृहीत्वा वासिष्ठो विष्णुचन्द्रेण' इत्युक्त्या स्फुटं भवति। परमयं ग्रन्थोऽधुना कुत्रापि नोपलभ्यते । एतस्यैव विष्णुचन्द्रस्य मतं यत्र तत्र श्रीषेणार्यभटाभ्यां सह ब्रह्मगुप्तेन खण्डितम् ।

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१. यथोदाहरणार्थं किञ्चित्प्रोच्यते । सिद्धान्तशेखरस्य सूर्यग्रहणाधिकारे ।

तिथ्यन्तात् स्थितिखण्डहीन सहितात् प्राग्वत्ततो लम्बनं
कुर्यात् प्रग्रहमोक्षयोः स्थितिदलं युक्तं विधायासकृत् ।
तन्मध्यग्रहणोत्थलम्बनभुवा विश्लेषणानेहसा
मर्दार्धोनयुताथितेरपि तथा संमीलनोन्मीलने ॥
अधिकमृणयोराद्यं मध्यात्तथाऽन्त्यमिहाल्पकं भवति
धनयोश्चाद्यं हीनं यदाऽधिकमन्तिमम् ।
नमनविवरेणैवं कुर्याद्विहीनमतोऽन्यथा स्थितिदल-
मृणस्वस्थे भेदे तदैक्ययुतं पुनः ॥

इति ब्रह्मगुप्तोक्तस्या—

प्राग्वल्लम्बनमसकृत् तिथ्यन्तात् स्थितिदलेन हीनयुतात् ।
अधिकोनं तन्मध्याहणयोरूनाधिकं धनयोः ॥
यद्यधिकं स्थित्यर्धं तदाऽन्तरेणान्यथोनमृणमेकम् ।
अन्यद्धनं तदैक्येनाधिकमेवं विमर्दार्धे ॥

(शेष पृष्ठ ११ पर)

न च श्रीपतिरेव निजपूर्ववर्त्तिनां ग्रन्थकाराणां ग्रन्थेभ्यस्तदुक्तविषयान् छन्दोऽन्तरेण तथैव निबध्य स्वग्रन्थे स्वोक्त्या लिखितवानपितु तत्पूर्ववर्तिनां ग्रन्थकाराणामपि सैव रीतिः। परवर्त्तिनो भास्कराचार्यादयोऽपि न तां रीतिममुञ्चन्निति प्रत्यक्षदर्शनादेव स्फुटीभवति।

यथा भास्कराचार्यः—गणिताध्यायस्य मध्यमाधिकारे सिद्धान्तग्रन्थलक्षणं ज्योतिः शास्त्रस्य वेदाङ्गत्व निरूपणं वेदाङ्गानां नामानि वेदाङ्गेषु ज्योतिः शास्त्रस्य प्राधान्यं तच्च द्विजैरेव पठनीयमिति सर्वं परतोऽपि भचक्रचलनं काल-

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ऽस्य सर्वथा सदृशमेव तथा च प्रकारान्तरेण स्फुट स्थिति दल साधनं श्रीपत्युक्तम्।

स्पित्यर्धोनयुतात् परिस्फुटतिथेः स्याल्लम्बनं पूर्ववत्
तन्मध्यग्रहवेच मध्यमतिथो ततस्तु तिथौ।
स्थित्यर्धेन परिस्फुटेषु जनितेनोनाधिकाद्वाऽसकृत्
तत्तिथ्यन्तर नाडिकाः स्थितिदले स्तः स्पर्शमुक्त्योः स्फुटे॥

अस्य श्लोकस्य द्वितीयं चरणं शुद्धं नास्ति। प्रकारोऽयं ब्रह्मगुप्तोक्तस्या—

स्फुटतिथ्यन्ताल्लम्बनमसकृत् स्थित्यर्धहीनयुक्ताद्वा।
तत्स्फुट विक्षेपकृत स्थित्यर्धोनयुततिथ्यन्तात्॥
तत्स्पष्टतिथिच्छेदान्तरे स्फुटे दिनदले विहीनयुतात्।
स्व विमर्दार्धेनासकृदेवं स्पष्टे विमर्दार्धे॥

ऽस्य पुनरुक्तिरेव। सिद्धान्तशिरोमणौ—

तिथ्यन्ताद्गणितागतात् स्थितिदलेनोनाधिकाल्लम्बनं
तत्कालोत्थनतीषु संस्कृति भव स्थित्यर्धहीनाधिके।
दर्शान्ते गणितागते धनमृणं वा तद्विधायासकृज्
ज्ञेयौ प्रग्रहमोक्ष संज्ञसमयावेवं क्रमात् प्रस्फुटौ॥

भास्करोक्तमपि सर्वथैव तदनुरूपमेवास्ति। एवं सिद्धान्तशेखरस्य सूर्यग्रहणाध्यायोपसंहारे स्फुटं भवति पञ्चजीवया लम्बनं नहि यतस्ततः कृतम्। युक्तमुक्तमिति जिष्णुसूनुना तन्मयाऽपि कथितं परिस्फुटम् इति ब्रह्मगुप्तोक्तस्या—

दृग्गणितैक्यं न भवति यस्मात् पञ्चज्यया रविग्रहणे।
तस्माद्यथा तदैक्यं तथा प्रवक्ष्यामि तिथ्यन्ते॥

ऽस्य सदृशमेव। मध्यगत्यध्यायतो ग्रन्थ समाप्ति यावत्साद्दृश्यस्यैवमेव स्थितिरिति द्वयोर्ग्रन्थयो 'ब्राह्मस्फुट सिद्धान्त सिद्धान्तशेखरयोः' रवलोकनेन स्फुटं भवतीति'।

प्रवृत्तिः। कालमानानां परिभाषाः सर्वाः, ग्रहाणां भगणाः, युगानां मन्वादीनां नामानि मानानि च ब्रह्मणो गतवर्षादिः प्रयोजनाभाव इत्यादि सर्वमपि मध्यमाधिकारोक्तं श्रीपतेः साधनाध्यायोक्तश्लोकानां श्लोकान्तरमात्रमेवाकरोत्। सुधियो ग्रन्थाभ्यन्तरे ग्रन्थकारयोरानुरूप्यमवलोकयन्तु। एवं प्राचीनकृतेरनेकान् विशेषान् प्रवक्तुमेव श्रीपतिः प्रथमं (साधनाध्यायं) ग्रहभगणाध्यायं वा कृतवान्। तत्परं मध्यमाध्यायेसप्तभिः प्रकारैरहर्गणानयनं, कदा प्रभृति वारप्रवृत्तिरित्यत्र बहूनामाचार्याणां मतानि, तद्दूषणपुरःसरस्वाभिमतवारप्रवृत्तिकथनं, मध्यमग्रहसाधनार्थं बहून्येव नूतनानि प्रकारान्तराणि, रव्यादीनां सर्वेषामपि ग्रहाणां राश्यादिमन्दोच्चकथनमित्यादयो बहवोऽपि श्रीपतिकृताप्राचीनकृतेर्विशेषा वर्त्तन्ते।

ब्राह्मस्फुट सिद्धान्ते बहुभिरेव प्रकारैरहर्गणानयनं लघ्वहर्गणानयनं ब्रह्मगुप्तेन कृतं, आचार्योक्ताहर्गणानयनस्यानुकरणमेव श्रीपतिना कृतम्। परं सिद्धान्तशेखरे लघ्वहर्गणानयनस्य चर्चा ग्रन्थकृता न कृता। अहर्गणाद्वारज्ञानार्थमहर्गणः सैकः कार्य इति ब्रह्मगुप्तेन श्रीपतिना च कथितः। परमहर्गणो निरेकोऽपि कर्त्तव्यो वारज्ञानार्थमिति सिद्धान्तशिरोमणौ 'अभीष्टवारार्थमहर्गणश्चेत्सैको निरेकस्तिथयोऽपि तद्वदि'त्यनेन भास्कराचार्यः कथयति। वटेश्वरसिद्धान्तेऽपि बहुभिः प्रकारैरहर्गणानयनं लघ्वहर्गणानयनं च तद्ग्रन्थकृता कृतमस्ति। भास्कराचार्यस्तु महदहर्गणानयनं 'कथितकल्पगतोऽर्कसमागण' इत्यादिना, लघ्वहर्गणानयनं च 'चैत्र सितादिगतस्थिति संघ' इत्यादिना कृतम्। यद्यपि लघ्वहर्गणानयने स्थौल्यं वर्त्तते तथाप्येकमपूर्वं वस्तु प्रतिपादितम्। वटेश्वरकृतं लघ्वहर्गणानयनं स्थौल्यरहितं नास्ति, एतदतिरिक्तैः प्राचीनाचार्यैर्नवीनैश्च लघ्वहर्गणानयनं न कृतं प्रत्युत कमलाकरेण भास्करकृतलघ्वहर्गणानयनस्य खण्डनमेव कृतम्। स्फुटगत्यध्याये सर्वैरेवार्यभटब्रह्मगुप्त लल्लाचार्यादिभिर्वृत्तचतुर्थांशे चतुर्विंशतिः क्रमज्या उत्क्रमज्याश्च तत्त्वाश्वि २२५ कलावृद्ध्या साधितास्तत्र आर्यभटस्य लल्लस्य च त्रिज्या=३४३८, ब्रह्मगुप्तस्य खमुनिरद ३२७०मिता त्रिज्या, श्रीपतिना चैतद्भिन्ना ३४१५ त्रिज्या गृहीता ब्रह्मगुप्तोक्तभूपरिधिः= ५०००, भास्कराचार्यमतेन पादोनगोक्षधृतिभूमितयोजनानीत्यनेन ग्रहाणां योजनगतिः=११८५८।४५। गतियोजनतिथ्यंशः कुदलस्य यतोमितिरित्यनेन भूव्यासः=१५८१, भूपरिधिः=४९६७ ग्रहाणां भुजान्तरकर्म प्रतिपादितमस्ति, सूर्यसिद्धान्तोक्त भुजान्तरकर्मवदेवास्ति, सिद्धान्तशेखरे, सिद्धान्तशिरोमणावपि भुजान्तरकर्मण उपपादनमाचार्योक्तवदेवास्ति, अन्येऽपि बहवो विषयादर्शनीयाः पठनयोग्याश्चेति।

त्रिप्रश्नाधिकारे रवेर्मध्यान्हकालिकनतांशान् ज्ञात्वा तद्वशतो रव्यानयनार्थं प्रथमतः क्रान्तिज्यासमागच्छति। ततोऽनुपातेन रवेर्भुजांशज्ञानं भवति।

भुजांशतो राश्यादिरवेर्ज्ञानं पदाधीनं तत्र पदज्ञानोपायः प्राचीनैः कैश्चिन्न कृतः, यथाऽत्राचार्येण—

'क्रान्तिर्व्यासार्धगुणा जिनभागज्याहृता धनुरजादौ ।
कर्क्यादौ चक्रार्धात्प्रोह्य तुलादौ सचक्रार्धम् ॥

चक्रार्धात्प्रोह्यमृगादौ स्फुटो सकृत् व्यस्तमृणं धनं मध्यम् । अर्कोऽस्मादिति' एतेन रवेरानयनं कृतम् । श्रीपतिना 'अजतुलादिगतस्य विवस्वतो दिनदलप्रभयो-र्युतिरर्धिता । भवति वैषुवती निजदेशजे' त्यनेन पलभामानं ज्ञात्वा—
'आद्येपदेऽपचयिनी पलभाऽल्पिका स्यात् छायाल्पिका भवति वृद्धिमती द्वितीये ।
छायाधिका भवति वृद्धिमती तृतीये तुर्येपुनः क्षयवती तदनल्पिका च ॥
वृद्धिं प्रयान्ती यदि दक्षिणाग्रच्छाया तथापि प्रथमं पदं स्यात् ।
ह्रासं व्रजन्तीमथ तां विलोक्य रवेर्विजानीहि पदं द्वितीयम् ॥'

इत्यनेन गोलयुक्तिसिद्धं पदज्ञानं कृतम् । अत्र भास्कराचार्यः—

क्रान्तिज्या त्रिज्याघ्नी जिनभागज्योद्धृता दोर्ज्या ।
तद्धनुराद्ये चरणे वर्षस्यार्कः प्रजायतेऽन्येषु ॥
भार्धाच्च्युतः सभार्धो भगणात्पतितोऽब्द चरणानाम् ।
ऋतुचिन्हैर्ज्ञानं स्यादृतुचिन्हान्यग्रतस्ततो वक्ष्ये ॥'

इत्यनेनाचार्योक्तवदेव कथितवान् केवलं 'ऋतुचिन्हैर्ज्ञानं स्यादिति' विशेषं कथितवान् । पदज्ञानार्थमृतुवर्णननामकमेकमधिकारं सिद्धान्तशिरोमणेर्गोला-ध्यायेऽभिहितम् । भास्करतो नवीनाः कमलाकरतः प्राचीनाः सर्वेऽपि सिद्धान्त-ग्रन्थकर्तारो ज्यौतिषसिद्धान्तस्यैकमङ्गं ज्ञात्वा स्वस्वसिद्धान्तग्रन्थे निश्चितरूपेण 'ऋतुवर्णनाध्यायं,' प्रोक्त'वन्तः । सिद्धान्ततत्त्वविवेके आद्ये पदेऽपचयिनी पलभाऽल्पिका स्या' दित्यादि श्रीपत्युक्त पदज्ञानबोधक श्लोकद्वयं लिखित्वा कमलाकरेण—

'ऋतुचिह्नैरिदं पूर्वैरुक्तं सर्वत्र तन्न हि ।
केवलं कुकविप्रीत्यै पदज्ञप्तचै न तद्रवेः ॥'

इत्यनेन भास्करोक्त ऋतुवर्णनं निन्दितम् । वस्तुतः 'सर्वत्र तन्नही'ति कमलाकरोक्तं यथार्थमेव । परं पदज्ञान प्रकारोऽयं श्रीपत्युक्त इति कमलाकरेण नोक्तः । सिद्धान्तशेखरस्याप्राप्तौ प्रकारोऽयं कमलाकरस्यैवेत्याधुनिका ज्योतिर्विदो जानन्त आसन् । यदि रवेः पदज्ञानार्थं कोऽपि प्रकारः प्राचीनैर्यथार्थतो नोक्तस्तदा प्रकारस्यास्य रचयिता श्रीपतिरवश्यमेव सर्वेषां ज्योतिर्विदां प्रशंसापात्रमित्यत्र न कोऽपि सन्देहः । महदाश्चर्यं चैतद्यत् श्रीपतिकृतमिदं गोलयुक्तियुक्तं पदज्ञानं

त्यक्त्वा भास्कराचार्येण ऋतुवर्णनद्वारा पदज्ञानं समीचीनं ज्ञात्वा कृतमिति। चन्द्रग्रहणाध्याये रविचन्द्रभुवां योजनबिम्बानि, रविचन्द्रयोर्योजनात्मककर्ण-स्पष्टीकरणं, भूभा बिम्बानयनं, ग्रासमानाद्यानयनं, परिलेखप्रकारश्चाचार्यैरुक्तः, श्रीपतिना भास्कराचार्येण च कथनक्रममादाय विशेषतया तथैवानूदितः। ब्रह्म-गुप्तकृत एव सूर्यग्रहणाधिकारः श्रीपतिना प्रायः श्लोकान्तरैरुक्तः। उदयास्तमया-ध्याये आयनदृक्कर्मसाधनं कृतं परं तन्न समीचीनं श्रीपतिनाऽपि प्राचीनोक्तं तदानयनं कृत्वा—

खनभोधृतिभिः समाहतं प्रथमं दृक्फलमायनाह्वयम्।
द्युचराश्रितभोदयासुभिर्विहृतं स्पष्टमिह प्रजायते॥

इत्यनेन तत्स्फुटीकरणं कृतं, एतदवलोक्य भास्कराचार्येण 'आयनं वल-नमस्फुटेषुणा सङ्गुणमि' त्यादिना तदेवोक्तम्। चन्द्राध्याये ब्रह्मगुप्तेन बहवो-विषयाः प्रतिपादिताः सन्ति, श्रीपतिना तु वराहब्रह्मगुप्तलल्लाचार्याणां बहवः श्लोका अनूदिताः। वस्तुतो नास्ति कश्चिद्विशेषः। केवलं चन्द्रस्य स्पष्टचरा-नयने परिलेखसूत्रप्रमाणानयने च बह्वन्येव प्रकारान्तराणि स्फुटोक्त्या लिखि-तानि सन्ति। वराहब्रह्मगुप्तलल्लाचार्यैरुदयान्तरकर्म नोक्तं ग्रहयुत्यध्याये (ग्रह-युद्धाध्याये-ग्रहयोगाध्याये वा)—

अन्त्यभ्रमेणगुणिता रविबाहुजीवाऽभीष्टभ्रमेण विहृता फलकार्मुकेण।
बाहोः कलासु रहितास्ववशेषकं ते यातासवो युगयुजोः पदयोर्धनर्णम्॥

इत्यनेन श्रीपत्युक्तं दृग्गणितैक्यकृत् कर्मैव भास्कराचार्येण उदयान्तर-कर्मेति नाम्नोक्तम्। सिद्धान्तशेखरस्याप्राप्तौ भास्कराचार्येणैवानुभूतमिदं कर्म-त्याधुनिकानां गणकानां प्रतीतिरासीत्। इदमुदयान्तरकर्म प्रथमं श्रीपतिरेव स्वकीय विचारेण कथयामासेति ज्ञायते। तथा च—

त्रिभविरहितचन्द्रोच्चोनभास्वद्भुजज्या गगननृपविनिघ्नी भत्रयज्या विभक्ता।
भवति चरफलाख्यं तत्पृथक्स्थं शरघ्नं हृतमुडुपतिकर्णत्रिज्ययोरन्तरेण॥१॥
परमफलमवाप्तं तद्धनर्णं पृथक्स्थे तुहिन किरणकर्णे त्रिज्यकोनाधिकेऽथ। स्फुट-दिनकर हीनादिन्दुतो या भुजज्या-स्फुटपरमफलघ्नी भाजिता त्रिज्ययाऽऽप्तम्॥२॥
शशिनिचरफलाख्यं सूर्यहीनेन्दुगोलात् तदृणमुतधनं चेन्दूच्चहीनार्कगोलम्।
यदि भवति हि साम्यं व्यस्तमेतद्विधेयं स्फुटगणितदृगैक्यं कर्त्तुमिच्छद्भिरत्र॥३॥

श्लोकत्रयेणानेन दृग्गणितैक्यार्थं श्रीपतिना चन्द्रे संस्कारविशेषो दत्तः। कस्मिन्नपि प्राचीनग्रन्थे नायं संस्कारो लिखितो वर्त्तते। यद्यपि—

इन्दूच्चोनार्ककोटिघ्ना गत्यंशा विभवा विधोः ।
गुणो व्यर्केन्दुदोः कोटयोरूपपञ्चाप्तयोः क्रमात् ॥
फले शशाङ्कतद्गत्योर्लिप्ताद्ये स्वर्णयोर्वधे ।
ऋणं चन्द्रे धनं भुक्तौ स्वर्णसाम्यवधेऽन्यथा ॥

इत्यनेनैतादृश एव चन्द्रसंस्कारो मुञ्जालाचार्येण 'लघुमानस'नामके करणग्रन्थे कथितः । परमेतयोः सदृशत्वाभावात्—श्रीपतिना वेधेन दृष्ट्वा ततो भिन्नोऽयं कथित इति प्रतिभाति । श्रीपत्युक्तोऽयं संस्कारो भास्कराचार्येणासकृद्दृष्ट्वा विवेचितस्तत्र स्वोपलब्धेर्विस्तारपूर्वकं प्रतिपादनार्थमेको 'बीजोपनय' नामको ग्रन्थः ५९ श्लोकात्मकः सिद्धान्तशिरोमणि रचनैकवर्षानन्तरं—

मयाय बीजोपनये यदन्ते सूर्योक्तमाद्यं परमं रहस्यम् ।
प्रकाशये गोप्यमपीह देवं प्रणम्य बीजं जगतां हितार्थम् ॥१॥
यद्यपि पूर्वमपीदं संक्षेपादुक्तमागमोक्तदिशा ।
नैतावतैव कश्चित् दृक्करणैक्याय कल्पते गणकः ॥२॥
दृक्करणैक्यविहीनाः खेटाः स्थूला न कर्मणामर्हाः ।
अत इह तदर्हतायै तात्कालिकबीजविस्तरं वक्ष्ये ॥३॥
पाता रवेस्तामसकीलकाख्यास्तेषां समाकर्षणतः शशाङ्कः ।
तत्तुङ्गशक्तिश्च निजस्वभावं विहाय नित्यं विषमत्वमेति ॥४॥
चन्द्राच्च तद्योगवियोगतश्च साध्यं हि भाद्यं विषमं यतः स्यात् ।
तस्माद्विधोरत्र विशुद्धिशुद्ध्यै विस्तार्यते बीजफलक्रियेयम् ॥५॥
एकेन पुंसा निखिलग्रहाणामन्तं प्रबोधो नहि शक्यतेऽतः ।
व्यासात्समासाच्च यथोपलब्धं प्रोक्तं मयेत्यादरणीयमेतत् ॥६॥

इत्यादिना सिद्धान्तशिरोमणिवद्वासनाभाष्यसहितो विरचित इति । भग्रहयोगाध्याये—

कृत्वापि दृष्टिकर्म श्रीषेणार्यभटविष्णुचन्द्रोक्तम् ।
प्रतिदिनमुदयेऽस्ते वा न भवति दृग्गणितयोरैक्यम् ॥१॥
भमुनिमृगव्याधानां यतस्ततो दृष्टिकर्म वक्ष्यामि ।
दृग्गणितसमं देयं शिष्याय त्रिरोषितादेयम् ॥२॥

इति ब्रह्मगुप्तेन पाण्डित्यपूर्णमुक्तम् । एतदेव यथार्थं बुध्वा तदुक्तो (ब्रह्मगुप्तोक्तः) भग्रहयुत्यध्यायः सम्पूर्णोऽपि स्फुटोक्त्याऽनूदितः श्रीपतिनेति ।

ब्राह्मस्फुटसिद्धान्तोत्तरार्धे परिकर्मविंशतिः (सङ्कलितम्, व्यवकलितम्, प्रत्युत्पन्नो गुणनम् । भागहारः, वर्गः, वर्गमूलम्, घनः, घनमूलम् । पञ्चजातयः, त्रैराशिकम्, व्यस्तत्रैराशिकम्, पञ्चराशिकम्, सप्तराशिकम्, नवराशिकम्, एकादशराशिकम्, भाण्डप्रति भाण्डं चेति) कथिताऽस्ति, सर्वत्रैव चतुर्वेदाचार्योक्ता उद्देशकाः (उदाहरणानि) सन्ति । सिद्धान्तशेखरेऽपि परिकर्मविंशतिः (अभिन्नाङ्कानां गुणन-भजन-वर्ग-वर्गमूल-घन-घनमूलानीति षट् ६, भिन्नाङ्कानां योगान्तर-गुणन-भजन-वर्ग-वर्गमूलानीति षट् ६, भाग प्रभाग-भागानुबन्ध-भागापवाहाख्य-जाति चतुष्टयम् ४, विलोमकर्म १, त्रैराशिकम् १, व्यस्त त्रैराशिकम् १, पञ्चराशिकम् १, इति) ब्रह्मगुप्तश्रीपत्युक्त विंशत्यां परिकर्मसु विषयवर्णने महानेव भेदोऽस्ति तद्विंशतेः परिकर्मणां नामानि बहुधा भिन्नानि सन्ति । भास्करोक्त-प्रकीर्णविषयाः (सङ्कलिततो भाण्डप्रतिभाण्डं यावत्) यादृशाः स्फुटरूपेण वर्णिताः सन्ति न तादृशा ब्रह्मगुप्तश्रीपत्योः परिकर्मविंशत्युक्तविषयाः । विषयास्तु ब्रह्मगुप्तौ-श्रीपत्युक्तौ-भास्करोक्तौ-समाना एव किन्तु तत्प्रति पादनरीतयो भिन्ना भिन्नाः सन्ति । एवमष्टौ व्यवहाराः (मिश्रक व्यवहारः, श्रेढी व्यवहारः, क्षेत्रव्यवहारः, खातव्यवहारः, चिति व्यवहारः, क्राकचिक व्यवहारः, राशिव्यवहारः, छायाव्यवहारः) ब्राह्मस्फुटसिद्धान्ते, सिद्धान्तशेखरे भास्करीय लीलावत्यां च सन्ति, एतेष्वष्टसु व्यवहारेष्वपि बहुधैवान्यादृशत्वमस्ति, सर्वेषु व्यवहारेषु ब्रह्मगुप्तोक्तश्रीपत्युक्तव्यवहाराभ्यां भास्करोक्तव्यवहारेषु-विषयाधिक्यं-विषय-प्रतिपादन स्फुटत्वं चास्ति, ग्रन्थत्रया (ब्राह्मस्फुटसिद्धान्तः, सिद्धान्तशेखरः, लीलावती च) वलोकनेनेति स्फुटं भवति, एतत्परं प्रश्नाध्यायोऽस्ति यत्र मध्यगत्युत्तराध्यायः, स्फुटगत्युत्तराध्यायः । त्रिप्रश्नोत्तराध्यायः । ग्रहणोत्तराध्यायः । शृङ्गोन्नत्युत्तराध्यायः । एतेषु पञ्चसूत्तराध्यायेषु सोत्तराः प्रश्नाः सन्ति, प्रश्नाश्चातीव विलक्षणाः सन्ति, येषामभ्यासेन पाठका अतीव ज्यौतिषसिद्धान्तविषयेषु-निपुणा भवितुमर्हन्ति प्रत्यध्यायमीदृशः सोत्तरप्रश्नक्रमलेखः किञ्चित् किञ्चिद्वटेश्वर-सिद्धान्ते-सिद्धान्तशेखरे चावलोक्यते । सिद्धान्तशिरोमण्यादौ नायं क्रमोऽस्ति । एतत्परं प्रश्नसहितः कुट्टकाध्यायोऽस्ति, ब्रह्मगुप्तोक्तकुट्टकाध्याये[1] श्रीपत्युक्त-भास्करोक्ताभ्यां विषयाधिक्यमस्ति किन्तु विषयकथनस्फुटता भास्करोक्तावेवास्ति, धनर्णादीनां सङ्कलितव्यवकलितादि-भास्करोक्तवदेवास्ति-सिद्धान्त-शेखरेऽपि, ततः परमेकवर्णसमीकरणं बीजमस्ति, भास्करोक्तैकवर्ण समीकरण-बीजतोऽल्पमेवास्ति । ततः परमनेकवर्णसमीकरणबीजमस्ति, ब्रह्मगुप्तमिदमपूर्व-

१. ब्रह्मगुप्तोक्त कुट्टकाध्याये बहवः प्रश्नास्तादृशाः सन्ति येषामुत्तरमतीवाऽऽनन्द-जनकमस्ति, येषामभ्यासेन पाठकास्तत्सम्बन्धिविषयाणामतिज्ञातारो भवितु-मर्हन्तीति ।

मस्ति, अत्र विषयाश्चाप्यधिकाः सन्ति, भास्करोक्तमप्यनेकवर्णसमीकरणबीजं विषयाधिक्येन सहितं विद्यते। किन्तु सिद्धान्तशेखरेऽतीव स्वल्पं तद्विद्यते। भावित-बीजं ब्रह्मगुप्तोक्ताच्छ्रीपत्युक्तं स्वल्प भास्करोक्तं चाधिकं विद्यते, सर्वत्रैव भास्क-रोक्तौ वैशद्यं वर्त्तते। एतत्परं वर्गप्रकृतिरस्ति, कनिष्ठे ज्येष्ठक्षेपाणां योगभावना-ऽन्तरभावना च ब्रह्मगुप्तोक्तादेवाऽऽदाय श्रीपतिना भास्करेण च विलिखिता, परं श्रीपतिना भावनास्वरूपं न प्रतिपादितम्। वर्गात्मकप्रकृतौ कनिष्ठज्येष्ठयो-रानयनं ब्रह्मगुप्तोक्तमेव बीजगणिते भास्करेण लिखितम्। परं श्रीपतिना तत्स-म्बन्धे किमपि न लिखितम्। शङ्कुच्छायादिज्ञानाध्यायो ब्रह्मगुप्तस्यापूर्वं वस्तु वर्त्तते सिद्धान्तशेखरे भास्करीय ग्रन्थे चैतदध्यायोक्ता विषया न सन्ति, वस्तुतो दर्शनीयोऽयमध्यायः। छन्दश्चित्युत्तराध्यायस्त्वेतादृशोऽस्ति, यत्रस्थश्लोकोपप-त्तीनां का कथा तद्व्याख्याऽप्यतिकठिना तेनैव हेतुनाऽद्यावधि तद्व्याख्योपपत्तिश्च कैरपि न लिखिता। गोलाध्याये-भूगोलसंस्थानं-देवासुरसंस्थानं-चक्रभ्रमण-व्यवस्थादेवादीनां रविभ्रमणस्थितिः, देवदैत्यानां राशिसंस्थानं-देवादीनां रवि-दर्शनकालः, भूगोले लङ्कावन्तीसंस्थानमित्यादयो विषयाः सन्ति—

भूपरिधितुर्यभागे लङ्काभूमस्तकात् क्षितितलाच्च।
लङ्कोत्तरतोऽवन्ती भूपरिधेः पञ्चदशभागे॥

इत्यनेन लङ्कोत्तरतो भूपरिधिपञ्चदशभागेऽवन्ती वर्त्तत इत्याचार्येण कथ्यते, आचार्यानुयायी भास्कराचार्यः सिद्धान्तशिरोमणेर्गोलाध्याये 'निरक्षदेशात् क्षितिषोडशांशे भवेदवन्ती' इति कथितवान्, चतुर्वेदाचार्यसम्मतः पाठश्च 'पञ्च-दशभागे, अयमेव, अत्राध्याये-आचार्योक्ता बहवो विषयाः सूर्यसिद्धान्तीयभूगोला-ध्याये तथैव सन्ति, मध्ये मध्ये उभयत्र (आचार्योक्ताध्याये-सूर्यसिद्धान्तीय-भूगोलाध्याये) विषयान्तराण्यपि सन्ति, सिद्धान्तशेखरस्य गोलाध्याये श्रीपति-नाऽपि कियन्तो विषया आचार्योक्तसदृशा एव कथिताः। 'यन्मूले तद्व्यासो मण्डललिप्ताकृतेर्दशहृतायाः' इत्यनेन परिधितो व्यासानयनं सूर्यसिद्धान्तोक्त 'तद्वर्गतो दशगुणात्पदं परिधिरि'त्यादेर्विलोमेन परिधितो व्यासानयनवदस्ति, श्रीपतिनापि 'कालः स्यात्परिधेर्वर्गाद्दिग्भक्ताच्च पदं त्विहे'ति प्रकारानुकूलैव त्रिज्या-तिथियुगाग्नि ३४१५ मिताऽस्तीति स्वीकृता भास्कराचार्येण 'व्यासे भनन्दाग्नि-हते विभक्ते खबाणसूर्यैः परिधिः सुसूक्ष्मः' इत्यनेन व्यासात्परिध्यानयनं कथ्यते। एतद्विलोमेन परिधितो व्यासानयनं भवेत्। परं केषामपि व्यासात्परिध्यानयनं परिधितो व्यासानयनं वा न समीचीनं तयोः (परिधव्यासयोः) सम्बन्धस्या-स्थिरत्वादिति।

ज्याप्रकरणे—आचार्येण यथा चापार्धांशज्याद्यानयनं कृतं तथैव सिद्धान्त-शेखरे श्रीपतिना सिद्धान्तशिरोमणेर्गोलाध्याये भास्करेण च कृतमिति तद्ग्रन्था-

वलोकनात्स्फुटमस्ति। भास्करेण 'अन्त्यज्योत्पत्त्यौ' बहवो विशेषाः प्रतिपादिताः सन्ति।

स्फुटगतिवासनायां—मन्दफलसाधनेऽपि कर्णानुपातेन यत्फलं तदेव समीचीनमिति कर्णः कथं न कृत इत्यस्य कारणम्—

त्रिज्याभक्तः परिधिः कर्णगुणो बाहुकोटिगुणकारः।
असकृन्मान्दे तत्फलमाद्यसमं नात्रकर्णोऽस्मात्॥

कथितम्। सिद्धान्तशेखरे—

त्रिज्याहृतः श्रुतिगुणः परिधिर्यतोदोः कोटचोर्गुणो मृदुफलानयनेऽसकृत्स्यात्।
स्यान्मान्दमाद्यसममेव फलं ततश्च कर्णः कृतो न मृदुकर्मणि तन्त्रकारैः॥

इति श्रीपत्युक्तश्लोक आचार्यो (ब्रह्मगुप्तो)क्त श्लोकस्यानुवादरूप एव, भास्कराचार्येणापि—

स्वल्पान्तरत्वान्मृदुकर्मणीह कर्णः कृतो नेति वदन्ति केचित्।
त्रिज्योद्धृतः कर्णगुणः कृतेऽपि कर्णे स्फुटः स्यात्परिधिर्यतोऽत्र॥
तेनाद्यतुल्यं फलमेति तस्मात् कर्णः कृतो नेति च केचिदूचुः।
नाशङ्कनीयं न चले किमित्थं यतो विचित्रा फलवासनाऽत्र॥

इह कर्णेन यत्फलमानीयते तदेव समीचीनम्। यन्मन्दकर्मणि कर्णो न कृतस्तत्स्वल्पान्तरादिति कथ्यते। मन्दकर्मणि मन्दकर्णतुल्येन व्यासार्धेन यद्वृत्तं तत्कक्षावृत्तम्। तेन ग्रहो गच्छति। यो मन्दपरिधिः पाठपठितः स त्रिज्यापरिणतः। अतोऽसौ कर्णव्यासार्धे परिणाम्यते। यदि त्रिज्यावृत्तेऽयं परिधिस्तदा कर्णवृत्ते क इति स्फुटपरिधिः। ततः स्वेनाहृते परिधिना भुजकोटिजीवे भांशैरित्यादिना यत्फलमागच्छति तत्त्रिज्यया गुणितं कर्णेनभक्तं यल्लब्धं तत्पूर्वफलतुल्यमेव फलमागच्छतीति ब्रह्मगुप्तमतम्। अथ यद्येवं परिधेः कर्णेन स्फुटत्वं तर्हि किं शीघ्रकर्मणि न कृतमित्याशङ्क्य चतुर्वेदः कथयति—ब्रह्मगुप्तेनान्येषां प्रतारणपरमिदमुक्तमिति। तदसत्। चले कर्मणीत्थं किं न कृतमिति नाशङ्कनीयम्। यतः फलवासना विचित्राऽस्तीति। अन्यत्सर्वं पूर्वकथितमेवेति।

ग्रहणवासनायां—छादकनिर्णयं कृत्वा राहुकृतं ग्रहणं न भवतीति वराहमिहिरादीनां मतं प्रतिपाद्य संहितामतमवलम्ब्य तन्निराकृतम्।

राहुकृतं ग्रहणद्वयमागोपालाङ्गनादि सिद्धमिदम्।
बहुफलमिदमपि सिद्धं जपहोमस्नानफलमत्र॥

लोक प्रथेयमिति कथयित्वा राहुकृतं ग्रहणं भवतीत्यत्र स्मृति वाक्यं वेदवाक्यं च प्रतिपादितम्। युक्त्या राहुकृतं ग्रहणं न भवति। परन्तु स्मृतिषु-पुराणेषु वेदेषु च राहुकृतं ग्रहणं प्रतिपादितमस्त्यतोऽत्र द्वयोर्मतयोः समन्वयः—

राहुस्तच्छादयति प्रविशति यच्छुक्लपञ्चदश्यन्ते।
भूछाया तमसीन्दोर्वरप्रदानात् कमलयोनेः॥
चन्द्रोऽम्बुमयोऽधःस्थो यदग्निमयभास्करस्य मासान्ते।
छादयति शमिततापो राहुश्छादयति तत् सवितुः॥

आचार्येण कृतः। सिद्धान्तशिरोमणेर्गोलाध्याये भास्कराचार्येण भूभाकृतं चन्द्रग्रहणम्। चन्द्रकृतं सूर्यग्रहणं प्रतिपाद्य स्मृतिपुराणादिमतेन साकं समन्वयार्थं—

राहुः कुभामण्डलगः शशाङ्कं शशाङ्कगश्छादयतीव बिम्बम्।
तमोमयः शम्भुवरप्रदानात्सर्वागमानामविरुद्धमेतत्॥

इति कथितम्। सिद्धान्तशेखरे राहुकृतग्रहणखण्डनार्थमेको 'राहुनिराकरणाध्यायः' नामकोऽध्यायोऽस्ति।[1] गोलबन्धाधिकारे महद्वृत्तानां (पूर्वापरवृत्त-याम्योत्तरवृत्त क्षितिजवृत्तादीनां) लघुवृत्तानां (मेषादिद्वादशराशीनामहोरात्र-वृत्तानि) रचनां बिधाय परमलम्बनावनत्योः स्वरूपं प्रतिपाद्य दृक्कर्मानयनं कृतमाचार्येण, यथाऽत्र ब्राह्मस्फुटसिद्धान्ते ब्रह्मगुप्तेन गोलबन्धः प्रतिपादितस्तथैव सिद्धान्तशिरोमणौ चास्ति। ग्रहर्क्षगोलयोः पञ्च स्थिरवृत्तानि (पूर्वापरम्, याम्योत्तरम्, क्षितिजम्, उन्मण्डलम्, बिषुवन्मण्डलम्) इति प्रतिपादितानि, एतानि कक्षामण्डलतुल्यानि महद्वृत्तानि ज्ञेयानि। ग्रहाणां चलवृत्तानि च—

मन्दनीचोच्चवृत्तानि = ७, भौमादीनां शीघ्रनीचोच्चवृत्तानि = ५। मन्द-प्रतिवृत्तानि—७, शीघ्रप्रतिवृत्तानि = ५ दृग्मण्डलं, दृक्क्षेपमण्डलं कक्षामण्डलं

१. शिद्धान्तशेखरे सूर्यचन्द्रयोर्ग्रहणयोराहोरकारणत्वेऽपि लोकमतश्रुति स्मृति संहितानां यथैक्यं भवति तथा तत्प्रतिपादनाय राहोरेव ग्राहकत्वं कथ्यते यथा—

विष्णुलूनशिरसः किल पङ्गोर्दत्तवान् वरमिमं परमेष्ठी।
होमदानविधिना तव तृप्तिस्तिग्मशीतमहसोरुपरागे॥
भूमेश्छायां प्रविष्टः स्थगयति शशिनं शुक्लपक्षावसाने।
राहुर्ब्रह्मप्रसादात् समधिगतवरस्तत्तमो व्यासतुल्यः॥
ऊर्ध्वस्थं भानुबिम्बं सलिलमयतनोरप्यधोवर्त्ति बिम्बं
संसृत्यैवं च मासव्युपरतिसमये स्वस्य साहित्यहेतोः।

चेति सप्तानां ग्रहाणाम्=२१, चन्द्रादीनां विमण्डलानि=६ सर्वेषां योगश्चल-वृत्तान्येक पञ्चाशत् सन्तीति, सिद्धान्त शेखरेऽप्येवमेवास्ति यथा—

मन्दोच्चनीचवलयानि भवन्ति सप्त शैघ्र्याणि पञ्च च तथा प्रतिमण्डलानि।
दृक्क्षेप दृष्टयपमजानि च खेचराणामर्कं विनैव खलु षट् च विमण्डलानि॥
पञ्चाशदेकसहितानि च मण्डलानि पूर्वापरं वलयमुत्तरदक्षिणं च।
क्ष्माजं तथा विषुवदुद्वलयाभिधाने पञ्च स्थिराणि कथितान्युडु खेचराणाम्॥

इति यन्त्राध्याये—

सप्तदश कालयन्त्राण्यतो धनुस्तुर्यगोलकं चक्रम्।
यष्टिः शङ्कुर्घटिका कपालकं कर्त्तरी पीठम्॥
सलिलं भ्रमोऽवलम्बः कर्णश्छाया दिनार्धमर्कोऽक्षः।
नतकालज्ञानार्थं तेषां संसाधनान्यष्टौ॥

इत्यने धनुर्यन्त्रम्। तुरीयम्। चक्रयन्त्रम्। यष्टिः, शङ्कुः, घटीयन्त्रम्। कपालयन्त्रम्। कर्त्तरीयन्त्रम्। पीठसंज्ञं यन्त्रम्। सलिलं (जलम्), भ्रमः (शाणः), अवलम्बसूत्रम्, छायाकर्णः, शङ्कुच्छाया, दिनार्धमानम्, सूर्यः, अक्षः (पलांशाः) नतकालज्ञानार्थं सप्तदश काल यन्त्राणि सन्ति, तेषां यन्त्राणां मध्ये सलिलादीन्यष्टौ यन्त्ररचना मूलकानि सन्ति, सिद्धान्तशेखरे 'गोलश्चक्रं कार्मुकं कर्त्तरी च कालज्ञाने यन्त्रमन्यत् कपालम्। पीठं शङ्कुः स्याद् घटी यष्टिसंज्ञं गन्त्री यन्त्राण्यत्र दिक् सम्मितानी' त्युक्त्य १ गोलयन्त्रम्, २ चक्रयन्त्रम्, ३ धनुर्यन्त्रम्। ४ कर्त्तरी नामक-यन्त्रम्। ५ कपाल यन्त्रम्। ६ पीठ (फलक) यन्त्रम्, ७ शङ्कुनामकयन्त्रम्। ८ घटीनामक यन्त्रम्, ९ यष्टि यन्त्रम्। १० गन्त्री (शकट) यन्त्रम्। इति दश-मितानि यन्त्राणि श्रीपत्युक्तानि सन्तीति। शिष्यधीवृद्धिद तन्त्रे द्वादश यन्त्राण्युक्तानि यथा—

गोलो भगणश्चक्रं धनुर्घटी शङ्कुशकटकर्त्तर्यः।
पीठकपालशलाका द्वादश यन्त्राणि सह यष्ट्या॥
कर्णच्छाया द्युदलं रविरक्षो लम्बको भ्रमः सलिलम्।
स्युर्यन्त्रसाधनानि प्रज्ञा च समुद्यमाश्चैवम्॥

भास्कराचार्येण सिद्धान्त शिरोमणौ दशैव यन्त्राण्युक्तानि। यथा—

गोलो नाडीवलयं यष्टिः शङ्कुर्घटी चक्रम्।
चापं तुर्यं फलकं धीरेकं पारमार्थिकं यन्त्रम्॥ इति।

सूर्य सिद्धान्तोक्त यन्त्राणि—

तुङ्गबीजसमायुक्तं गोलयन्त्रं प्रसाधयेत् ।
गोप्यमेतत्प्रकाशोक्तं सर्वगम्यं भवेदिह ॥

कालसंसाधनार्थाय तथा यन्त्राणि साधयेत् ।
एकाकी योजयेद्बीजं यन्त्रे विस्मयकारिणि ॥

शङ्कुयष्टिधनुश्चक्रैश्छायायन्त्रैरनेकधा ।
गुरूपदेशाद्विज्ञेयं कालज्ञानमतन्द्रितैः ॥

तोययन्त्रकपालाद्यैर्मयूरनरवानरैः ।
ससूत्ररेणुगर्भैश्च सम्यक् कालं प्रसाधयेत् ॥

पारदाराम्बुसूत्राणि शुल्बतैलजलानि च ।
बीजानि पांसवस्तेषु प्रयोगास्तेऽपि दुर्लभाः ॥

ताम्रपात्रमधश्छिद्रं न्यस्त कुण्डेऽमलाम्भसि ।
षष्टिर्मज्जत्यहोरात्रे स्फुटं यन्त्रं कपालकम् ॥

नरयन्त्रं तथा साधु दिवा च विमले रवौ ।
छाया संसाधनैः प्रोक्तं कालसाधनमुत्तमम् ॥

मानाध्याये—

मानानि सौरचान्द्रार्क्षसावनानि ग्रहानयनमेभिः ।
मानैः पृथक् चतुर्भिः संव्यवहारोऽत्र लोकस्य ॥

इत्यनेन सौरचान्द्रनाक्षत्रसावनमानानि कथितानि, एभिरेव चतुर्भिर्मानैर्लोकिानां व्यवहारा भवन्ति । केन केन मानेन के के पदार्था गृह्यन्ते इति सर्वे प्रतिपादिताः सन्ति, ब्राह्मं, दिव्यं, पित्र्यं, प्राजापत्यं, बार्हस्पत्यं, सौरं, सावनं, चान्द्रं, नाक्षत्रमिति नव मानानि सन्ति, एतेषु नवमानेष मनुष्यलोके मानचतुष्टयानां (सौर चान्द्रार्क्ष सावनानां) प्राधान्यम्, यतस्तैरेव तेषां व्यवहारा दृश्यन्ते । सूर्यसिद्धान्त-सिद्धान्तशेखर-सिद्धान्तशिरोमण्यादिषु सर्वेषु ग्रन्थेषुमानानां सम्बन्धे समानरूपेणैव सर्वं प्रतिपादितमस्ति । ब्राह्मस्फुटसिद्धान्तेऽध्याये भूभादैर्घ्यं भूभामानञ्चापि प्रतिपादितमस्ति ।

संज्ञाध्याये—संज्ञाकथनकारणम् । सिद्धान्त एक एवास्ति, कस्मिन्नंशे सूर्यसिद्धान्तादयो भिन्नाः सन्तीति प्रतिपाद्य स्वसिद्धान्तोत्तरार्धेऽनुक्रमणिकाः कथिता आचार्येण, नान्येषु-सूर्यसिद्धान्त-सिद्धान्तशेखरादिसिद्धान्तग्रन्थेषु संज्ञाध्यायः । अध्यायोपसंहारात्पूर्वमेकः प्रश्न विशेषः—

आग्नेये नैर्ऋत्ये वेष्टदिने संस्थितस्य योऽर्कस्य ।
शङ्कुच्छाये कथयति वर्षादपि वेत्ति सूर्यं सः ॥
कथितोऽस्ति यदुत्तरं कोणशङ्कोरानयनेत स्फुटमस्ति ।
संज्ञाध्यायकथनस्य किमपि प्रयोजनं नासीत् ॥
आचार्येण कथमेतस्याध्यायस्योल्लेखः कृत इति न जानीमः ।

ध्यानग्रहोपदेशाध्याये—चैत्रादौ मासगणानयनम् । चैत्रादौ दिनादिकं तिथिध्रुवसाधनम् । इष्टमासादौ रव्यानयनम् । प्रतिमासं शशिकेन्द्रतिथिध्रुवक्षेपयोगानयनम् । प्रतिदिनचालनम् । चन्द्रसाधनमौदयिकरविसाधनञ्च । ज्याखण्डकानि केन्द्रज्या साधनञ्च यथा —

त्रिंशत् सनवरसेन्दुजिनतिथिविषया गृहार्धचापानाम् ।
अर्धज्याखण्डानि ज्याभुक्तैक्यं स भोग्य फलम् ॥
गतभोग्यखण्डकान्तरदलविकलवधाच्छतैर्नवभिराप्तैः ।
तद्युतिदलं युतोनं भोग्यादूनाधिकं भोग्यम् ॥

इत्याचार्योक्तभोग्यखण्डस्पष्टीकरणमेव सिद्धान्तशिरोमणेर्ग्रहगणिताध्यायस्य स्पष्टाधिकारे 'यातैष्ययोः खण्डकयोर्विशेषः शेषांशनिघ्नः' इत्यादिना भास्कराचार्येण कथितम् । भास्कराचार्येण खार्क-१२० मिता त्रिज्या गृहीता, अत्राचार्येण खतिथि १५० मिता त्रिज्या गृहीता । इत्यतीववैचित्र्यं यत्सर्वत्रैव श्रीपतिनाऽऽचार्यश्लोकोक्तविषया एव छन्दोन्तरेण लिखिताः परं किं कारणं यदपूर्वं भोग्यखण्डस्पष्टीकरणं न लिखितम् । चन्द्रे भुजफलसंस्कारः, तिथौ फलसंस्कारश्च । इत्यादयः सर्वे विषया अपूर्वाः सन्ति । अत्राध्याये ये केचन विषया लिखिताः सन्ति ते सूर्यसिद्धान्ते सिद्धान्तशेखरे, सिद्धान्तशिरोमणौ न सन्ति ।

अनुगृहीतोऽस्म्यहं श्रीडाक्टर सत्यप्रकाश डी० एस० सी० महोदयानां यैराङ्गलभाषायां कृपया ग्रन्थस्यास्य प्रस्तावना समरचि ।

सम्पादकमण्डलस्यान्ये सहयोगिनः ज्योतिषाचार्याः श्रीमुकुन्दमिश्राः, श्रीविश्वनाथ झा, श्रीदयाशंकरदीक्षिताः, शास्त्रिणः श्रीओंदत्तशर्माणश्च सर्वे एव मम धन्यवादस्य पात्रतामर्हन्ति । एतेषाममूल्यसहयोगेनैवायं महान् ग्रन्थः सुचारुरूपेण सम्पूर्णतामगच्छत् ।

'पद्मश्रीप्रकाशनालयस्य' स्वामिने रमेशचन्द्रशर्मणेऽपि धन्याञ्जलिर्भवतु यस्य महता परिश्रमेण ग्रन्थस्य प्रकाशनं कालेनैवाभवत् ।

अन्येभ्यः सर्वेभ्योऽपि धन्यवादान् प्रददे, यैरल्पमपि साहाय्यं विधायाहं कृतार्थीकृतोऽस्मि, इति शम् ।

भृगु-आश्रमः
३०-३-६६

विदुषामनुचरः
रामस्वरूप शर्मा

श्रीब्रह्मगुप्ताचार्यं विरचितः

विभिन्नपाठान्तरसहितो

ब्राह्मस्फुटसिद्धान्तः

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CHAPTER I

Astronomy in Ancient Nations

Brahmagupta's great works like the *Khaṇḍakhādyaka* and *the Brāhma-sphuṭa-siddhānta* took astronomy to Arabs through whom it spread to many countries of Europe. Al Beruni records this testimony in his great book on India. It is doubtful that astronomy had its birth in Greece and China. From remote ages China, India, Greece, Arabia and Egypt developed the entire system in close cooperation. This knowledge must have spread from their common cradle home where man for the first time developed his culture and civilisation. In this chapter we propose to give a review of astronomy as developed in many of these ancient lands, especially Arabia, people of which land came in close contacts with India much before any recorded time.

Dawn of Astronomy

The earliest man must have been the primitive astronomer. The striking spectacles presented to him by the varied appearances of a sky covered with thousands of twinkling and non-twinkling objects of different degrees of brightness, apparently revolving round the Earth, and the daily changing phases of the Moon must have raised strange feelings of the most primitive man also. Then he must have in course of time observed the bright morning and evening stars, and at a considerably late stage the comets and shooting stars and then on occasions eclipses of the Sun and the Moon. These phenomena not only raised feelings of admiration, but in different sections of human society often feelings of superstitious alarm. By and by stars became guides for the traveller by land and sea. In the midst of these observations, one discovered various cycles : cycle of day and night, cycle of seasons and cycle of other details. Then there was a striking observation of the tides in a sea changing with the phases of the Moon.

Earliest Discoveries

We shall briefly sketch out the order of astronomical discoveries. The first phenomena to be noted must have been the regularly recurring dawn (for this one may refer to the Uṣā Sūkta of the *Ṛgveda*), the sunrise and sunset (which led to *prātaḥ* and *sāyam*, *i.e.* morning and evening prayers of the Vedic times), daylight, twilight and night concerning which we have numerous Vedic hymns. Next it led to the measurement of a day (which was of a short duration in winters and of a long duration in summers). The Vedic Aryans also discovered the variations in the duration of the day along different latitudes, and the time of sunrise in places of different longitudes. In fact the idea of longitudes and latitudes came sufficiently afterwards. Man discovered month as related to the variation of light with the Moon's phases. In temperate regions, where probably the first astronomical observations were systematically made, the changing length of the day or the direction of the Sun at rising or setting or the lengths of shadows cast at midday, would show that the Sun's daily path in the sky altered throughout the year, a time interval which was already marked by the changing vegetation. According to Sir W.C. Dampier, "attempts were made to determine the number of months in the cycle of the seasons in Babylonia about 4000 B. C. and in the China soon after. About 2000 B. C. the Babylonian year settled down to one of 360 days or twelve months, the necessary adjustments being made from time to time by the interposition of extra-months." In India, this concept is of even much earlier origin. The old inspired sages like Dīrghatamas discovered for the observing man the Vedic Era and intercalation. I have described this discovery in a special chapter on the subject in my book the *Founders of Sciences in Ancient India* and a reference may be made to the *Asya Vāmasya Sūktam* of the *Ṛgveda*. It is impossible to assign an age to these old traditions. Round the *Yajña*, developed the science of astronomy, mathematics, anatomy and medicine in this ancient land of ours, which in fact was the common heritage of a large number of people of the modern world.

One might also say that a considerable period might have well elapsed before it was noticed that at a particular season of

the year, the same stars are seen at corresponding hours of the night. Of course this circumstance was less conspicuous than the regular variation of the Sun's altitude in the sky as the year progresses. It is the surmise that the striking naked-eye cluster, the Pleiades, must have been one of the earliest noted star-groups, and it became the first star-group for providing the first fairly close determination of the length of the year as approximately 365 days. The rising of this cluster in the evening was a mark of the coming winter to primitive man; and the husbandman judged the time of reaping by its rising, and of ploughing by its setting in very ancient times; Sirius, Arcturus, the Hyades and Orion were similarly equally useful to him. The passages in the *Taittirīya Saṁhitā* and in the *Śatapatha Brāhmaṇa* clearly indicate the confusion once created by following the concept of lunar months without further adjustments:

> "Now the seasons were desirous to have a share in the sacrifice among the gods and said, 'Let us share in the sacrifice. Do not exclude us from the sacrifice! Let us have a share in the sacrifice!' The gods, however, did not approve of this. The gods, not approving, the seasons went to the Asuras, the malignant, spiteful enemies of the gods. Those (Asuras) then throve in such a manner that they (the gods) heard of it, for even while the foremost (of the Asuras) were still ploughing and sowing, those behind them were already engaged in reaping and threshing: indeed even without tilling, the plants ripened forthwith for them. (*ŚBr*. I.6.1.1-3)

The Zodiac

It is difficult to say how much time it must have taken, but in fact, it was eventually noted that the Sun and Moon travel over very similar paths among the stars during their circuit of the sky. This led to the formation of the Zodiac and its constellations, the centre of this zone, a belt about 16° broad, being the annual path of the Sun or Ecliptic. The division into twelve parts, each corresponding to a month of the Sun's movement, was made; and their connection with the solar course during the year was found by observations of heliacal risings or settings. These were the times of the year when certain bright stars would first be seen to rise before the Sun, or when

they were last seen to set after sunset. In the case of Ṣirius, the brightest fixed star, these would happen when the Sun was about ten degrees below the horizon. For the less bright stars the angle would be a larger one.

It must have been almost simultaneously observed that the Moon in going like the Sun round the heavens always in the same direction from west to east (i. e., opposite to the diurnal motion which she shares with the other bodies), kept in general to the same track in the sky. After a time, however, it must have been noted by careful observers that this path was not constant, but deviated from the centre line of the Zodiac, getting away from that line up to a maximum deviation on either side but slowly returning to it. In the course of a number of years, it must have become evident that the Moon's path among the stars does not lie always in the same line on the celestial sphere, but in a zone or band about twenty moon breadths (10°) wide, occupying the middle of the Zodiacal zone itself.

Among the bright stars Mercury, Venus, Mars, Jupiter and Saturn (the first two of which are never seen very far from the Sun in the sky) soon must have been noted to be moving in the Zodiac with varying periods. The English name *planet* is derived from Greek *planetes,* meaning a wanderer, since the planets change their positions among the Zodiacal stars.

There is a word *Stṛ* which in the *Ṛgveda* always occurs in the instrumental plural, *Stṛbhiḥ.* The English word star is derived from this word. Parāśara and Gṛtsamada, I have shown elsewhere, were the first amongst the great observers, inspired by the Ṛgvedic hymns, and Vāmadeva identified Bṛhaspati or the Jupiter planet and Vena Bhārgava discovered tht planet Venus which still bears the name of its discoverer.

Constellations

Long before the Zodiacal belt was divided into "signs" (700 B. C.), a number of asterisms, or the configuration of stars in the sky had been arranged, the brighter stars of these configurations, thus identified, proved very useful in indicating the seasons of the year by the times of their rising or setting, and also in locating the positions on the celestial vault of such moving objects as planets, comets and shooting stars and in helping the traveller by land or sea to determine direction.

These named constellations date back to very early period. In India, Gārgya is the name of an astronomer who is associated with a hymn of the *Atharvaveda* which for the first time enumerates constellations. In many of these constellations, the stars form a well marked group, clearly separated from other groups, and the names given to these formations are supposed to have been suggested by a resemblance to the shapes of certain familiar objects. Of course, the resemblance is usually very slight, and depended merely on a fancy.

It is remarkable that different countries devloped almost similar notions regarding these constellations. The late Dr. A. C. D. Crommelin considered that there is a reason to believe that the stars may have been grouped to some extent by the Egyptians as early as 4000 B. C., and he remarked on their use of the then Pole Star for orienting the Great pyramid, Again, Chinese are said to have mapped out the sky into many divisions of stars by 2500 B. C., if one can rely on their records.

The idea of constellations takes us to a date much earlier than 2500 B. C. even. In total forty-eight have come down from extremely ancient times, but these do not cover the entire extent of the sky. The part not occupied by any of them evidently did not rise above the horizon where the early astronomers to whom we owe their naming lived; and the stars concerned were therefore not included in their constellation schemes. The centre of this part (near the bright star Achernar) must have been near the South Pole of the heavens of the time, and its angular radius from the Pole gives us roughly the latitude of their homes. The date appears to have been about 2800 B. C., when, owing to the precession of the equinoxes, the South celestial pole was in the position indicated. The latitude seems to have been about 38° North. These are the findings of E. W. Maunder (*Astronomy without a Telescope*, p.5, 1902); but from the same considerations Dr. Crommelin assigns a latitude of 36° and a date 2460 B.C. and Proctor 2200 B. C. Maunder also suggested that the presence of the Lion and Bear among the stellar configurations and the absence of Elephant, Tiger, Camel and Crocodile seem to exclude India towards the East and the countries towards the West, the latitude and the longitude indicated being those of Asia Minor or Armenia. The suggestion that the blank area in

the sky referred to gave an approximate date for the formation of the constellations appears to have beeen first put forward in 1807 by Carl Schwartz, for some time Swedish Consul at Baku.[1]

Indo-Greek Contacts

It is highly improbable that before Alexander, there had been absolutly no contacts between India and the distant nations. Even in pre-Alexandrian era, there had been such migration is clearly evinced by the philological and mythological studies. But we do not pcssess historic record of it.

The conquests of Alexander the Great made the Greeks acquainted with the Eastern world, which had up to that time been visited probably by very few Europeans, and it likewise spread Greek culture to all the countries which the victorious Macedonian had been able to reach. The Indian province of his Empire became independent soon after Alxander's death and though the spread of Buddhism in the third century B. C. checked the progress of Hellenism in Northern India, the rise of the Greek kingdom of Bactria and its gradual extension south and east continued for a long time to keep alive the connection between India and the West. Not only (as has beeen asserted) the Greek and Indian drama and architecture have been strongly influenced by Hellenistic and Indian contacts, it is beyond a doubt that the entire astronomy of the two great nations is the offspring of these mutual contacts.

In earliest times astronomy had only been cultivated in India and in no other country. Some idea had been acquired during those days of the periods of the Sun and Moon and the planet Venus and Bṛhaspati (Jupiter), which were used for chronological purposes, the lunar motions being specially connected with the proper times for sacrificial acts. The Vedic era was discovered during this period by Viśvāmitra, and Gārgya enumerated the Nakṣatras. Lagadha composed his *Vedāṅga Jyotiṣa*, which is the *first* book on astronomy written in human literature. India developed her geometry in connection with the construction of sacrificial altars, and its account is found in the *Śulba Sūtras* of Baudhāyana, Āśvalāyana and Kātyāyana. Āryabhaṭa laid the foundations of algebra. One might still say that there is no sign of

1. See, Peter Doig : *A concise History of Astronomy*. London, 1950.

accurate knowledge of the planetary motions earlier than about the century of the Christian era. From thenceforth astronomy, hitherto confined to rituals, appears as a science, treated in the course of the next thousand years in a series of text-books, the *Siddhāntas*,[1] the contents of which, though supposed to be derived from divine sources are strongly influenced by Greek authors. Prior to the Greek influence, we had ceremonies like dvādaśāha (lasting for twelve days), ṣaḍaha (lasting for six days), tryaha (lasting for three days) besides darśa-pūrṇamāsa ceremonies connected with the New Moon and Full Moon. But the week of seven days (*Saptāha*) was unknown in India. This concept of week and the dedication of each day to the deity of one of the seven planets, now appears for the first time. It is difficult to say whether names of the planets were borrowed by Greeks from India or vice versa, but they became common, e.g., Aśvajit or *Asphudit* (Aphrodite). *Dyugatiḥ* or *dyaus* or *Jīva* (Zeus), Heli (Helios), &c., while the zodiacal signs have superseded the earlier but totally different twelve star-groups connected with the Sun's motion, and proclaim their origin by their names:

Kriya, Tāvuri, Jituma, Karkin, Leya, Pāthena, Jūka, Kaurpya, Taukshika, Ākokera, Hridroga, Ittha,

corresponding to *Κριός, Ταῦρος, Δίδυμος, Καρκίνος, Λέων, Παρθένος, Ζυγόν, Σκορπίος, Τοξότης, Αἰγόκερως, Ὑδροχόος, Ἰχθύς*[2].

A great many other Greek terms connected with geometry, astronomy and astrology have also been transferred from Sanskrit works to Greek and vice versa. This conclusively shows the mutual influence on astronomy. Indian authors never failed to acknowledge the ideas they borrowed from Greeks, e.g. Varāhamihira quotes the Yavanas or peoples of the west as authorities for some of the scientific statements he makes. The name of the Romaka Siddhānta (which is at least as old as A.D. 400) also points in an unmistakable manner to its origin in one of the provinces of the Roman Empire.

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1. The *Romaka* or *Pauliśa Siddhānta* (before 400 A. D.), See Varāhamihira's the *Pañcasiddhāntikā* (about 570 A,D., Varāhamihira died in 587 A.D.). The original *Sūrya-siddhānta* was prior to Varāhamihira, the modern edition is perhaps of the 13th century. See J. Burgess "*Notes on Hindu Astronomy*" J. R. A. S., October 1893, p. 742.

Earth as a Sphere

The astronomers of the *Siddhāntas* taught that the Earth is a sphere, unsupported in space, and they reject the ancient mythological notion that it is supported by some animal like śeṣanāga (serpent), kacchapa (tortoise), or diggajas (elephants) which in turn rest on another, and so on, until the support of the last one after all has to be left unexplained. Bhāskara II, about A.D. 1150, who comments on the absurdity of this, also rejects the idea that the Earth is perpetually falling, since it would fall faster than an arrow shot upwards, on account of being heavier, so that an arrow could never again reach the Earth.[1] Round the Earth the planets are moving, all with the same linear velocity. The diameter of the Earth is 1600 yojanas, the distance of the Moon is 51,570 yojanas (or 64.5 times the radius of the Earth, nearly equal to Ptolemy's greatest distance, 64⅙), while the distances of the other planets result from the assumption of equal velocities.[2] The equation of centre of the planets is found by an epicycle and to this arrangment the Hindus add one of their own invention, by assuming that the epicycle had a variable circumference, greatest when the planet is at apogee or perigee and least at 90° from these, when the equation reaches its maximum. This contrivance of an oval epicycle was by some astronomers applied to all the planets, by others (Brahmagupta and Bhāskara) only to Mars and Venus, by others it was altogether rejected.[3] Why they complicated the calculation in this way is not clear. Āryabhaṭa I of Kusumapura or Pāṭaliputra, born A.D. 476, made another deviation from the Alexandrian doctrines, as appears in the *Brāhma-sphuṭa-siddhānta* of Brahmagupta, wherein he quotes the following from Āryabhaṭa: "The sphere of the stars is stationary, and the Earth, making a revolution, produces the daily rising and setting of stars and planets." Brahmagupta rejects this idea, saying: "If the Earth moves a minute in a prāṇa, then whence and what route does it proceed? If it revolves, why do not lofty objects fall?" But his commentator Caturveda Pṛthūdaka Svāmī replies: "Āryabhaṭa's

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1. *As. Res.* XII. p. 229 (*Essays*, II, p. 394).
2. The distances are proportional to the orbital periods of revolution, but for Mercury and Venus to the periods in the epicycles.
3. For further details see *As. Res.* II. p. 251 (Davis) and XII. p. 236 (Colebrooke, also *Essays*, II. p. 401).

opinion appears nevertheless satisfactory, since planets cannot have two motions at once : and the objection, that lofty things would fall, is contradicted; for every way the under part of the Earth is also the upper; since wherever the spectator stands on the Earth's surface, even that spot is the uppermost spot.[1]

Earth rotation by a current of aerial fluid

It is very interesting to see the theory once advocated by Herakleides of Pontus transplanted on Indian soil, especially when we remember that Seleukus, the Babylonian, had adopted that theory. From Babylon the theory might easily find its way to India, though it is of course equally possible that Āryabhaṭa, quite independently of his Greek precursors, hit on the same idea. He appears to have accounted for the Earth's rotation by a wind or current of aerial fluid, the extent of which, according to the orbit assigned to it by him, corresponds to an elevation of little more than a hundred miles (114) from the surface of the Earth, or fifteen yojana's while he put the diameter of the Earth equal to 1050 yojanas (of 7.6.miles each[2]). This was in accordance with the general opinion of the Indians, that the planets are carried along their orbits by mighty winds with the same velocity and parallel to the ecliptic (while one great vortex carries all stars round the Earth in twenty-four hours, but that the planets are deflected from these courses by certain invisible powers having hands and reins, with which they draw the planets out of their uniform progress. The power at the apogee, for instance constantly attracts the planet towards itself, alternately with the right and left hand (like Lachesis in Plato's *Republic*), while the deity at the node diverts the planet from the ecliptic first to one side and then to the other. And lastly the deity at the conjunction causes the planet to move with variable velocity and to become occasionally stationary and even retrograde. This is gravely set forth in the *Sūrya-śiddhānta* ,and even Bhāskara gives the theory in his notes, though he omits it from his text. Similarly Brahmagupta, although he gives the theory of eclipses, affirms the existence of an eighth planet, Rāhu, which is the immediate cause of eclipses; and he blames Varāhamihira,

1. *Asiat. Res*, XII. p. 227; Colebrooke's *Essays*, II. p. 392.

2. Colebrooke, *Notes and Illustrations to the Algebra of Brahmagupta*. p. xxxviii.' *Essays*. II. p. 467.

Āryabhaṭa and others for rejecting this orthodox explanation of the phenomenon.[1]

Indian astronomy some times appears to be a curious mixture of old fantastic ideas and sober geometrical methods of calculation. But it is wrong to presume that these geometric calculations were derived from froeign contacts. Indians have always been fond of geometry (from the earliest times of the Vedic rituals), and they from the very beginning realised the importance of applying geometry to astronomy, Side by side we find Greek contacts also. As remarked by Colebrooke, the absence of the most characteristic parts of Ptolemy's system, the equant and the details of the theories of the Moon and Mercury seems to indicate that Greek planetary theory must have been introduced in India between the times of Hipparchus and Ptolemy; and with the exception of the epicycle from the circular form, the Hindus did not modify the theory or perfect it in any way. The precession of the equinoxes they held to consist in a liberation within the limits of 27° (Āryabhaṭa says 24°) east and west of its mean position, but they came much nearer to the truth than Ptolemy did as regards the annual amount, as they supposed the space travelled over in a century to be $1\frac{1}{2}$°.

Contacts with Arabs

Notwithstanding some isolation of India from Europe during the Middle Ages, her astronomy was destined to exercise an indirect influence on the progress of astronomy. Through the conquest of Persia in the seventh century, the Arabs, like the Greeks a thousand years earlier, came in contact with India, from whence physicians and astrologers found their way to the court of the Caliph already before the reign of Harun al Rashid. We possess a detailed account of the manner in which the Indian astronomy was introduced at Baghdad, from the pen of the astronomer Ibn al Adami (who died before 920), confirmed by the celebrated memoir on India by Al Beruni, written in 1031[2]. In the year 156 of the Hijra (A. D. 773), there appeared before the Caliph Al Mansur a man who had come from India; he was skilled in

1. *Asiat. Res.* XII, pp. 233, 241; *Essays*, II, pp. 398, 407,
2. Hankel, *Zur Geschichte der Mathematik im Alterthum* and *Mittelalter*, Leipzig, 1874, p. 229; Cantor, *Gesch. d, Math.* I. p. 656.

the calculus of the stars known as the Sindhind (i. e. Siddhānta), and possessed methods for solving equations founded on the kardagas (i. e. kramajyā, sines) calculated for every half degree, also methods for computing eclipses and other things. Al Mansur ordered the book in which all this was contained to be translated into Arabic, and that a work should be prepared from it which might serve as a foundation for computing the motions of the planets. This was accordingly done by Muhammed ben Ibrahim Al Fazari, whose works the Arabs call the great *Sindhind*, and from it an abstract was afterwards made for Al Mamun by Abu Giafar Muhammed ibn Musa al Kwarizmi, who made use of it to prepare his tables, which obtained great renown in the lands of Islam. But when Al Mamun became Caliph, he promoted these noble studies and called in the most learned men in order to examine the *Almagest* and make instruments for new observations.

Arabs and Greeks

The account of which the above is an abstract shows us clearly the origin of the study of astronomy and mathematics under the Abbasid Caliphs. But though the first impulse came from India the further development of Arabian science was to a considerable extent founded on that of Greece and Alexandria. It was through the court physicians from the flourishing medical school kept up by Nestorian Christians of Khusistan that a knowledge of Greek Philosophy and science was first spread among the subjects of the Caliphs; and by degrees the works of Aristotle, Archimedes, Euclid, Apollonius, Ptolemy, and other mathematicians were translated into Arabic. Fresh translations of Ptolemy were made from time to time in the various kingdoms into which the vast empire of the Caliph was soon split up,[1] and a thorough knowledge of Ptolemaic astronomy was thus spread from the Indus to the Ebro. There were several special inducements for Muhamedans to pay attention to astronomy, such as the necessity of determining the direction in which the

1. The earliest is probably that of Al Haggag ben Jūsuf ben Matar early in the ninth century. See Suter, *Die Mathematiker und Astronomen der Araber und ihre Werke*, Leipzig, 1900 (p. 9), which valuable bibliograpical summary has been follwed by J. L. E. Dreyer as regards names and dates (J. L. E. Dreyer's *A History of Astronomy*, 1953; we have reproduced this account from his chapter XI.)

faithful had to turn during prayers, also the importance of the lunar motions for the calendar, and the respect in which judicial astrology was held all over the East. The Caliph Al Mamun, son of Harun Al Rashid (813-833) is the first great patron of science, although the Omayyad Caliphs had much earlier an observatory near Damascus, and the Jew Mashallah (who died about 815) had already before the reign of Al Mamun won a name as an observer and astrologer. But the Damascus observatory became quite eclipsed by that erected at Baghdad in 829 where continuous observations were made and tables of the planetary motions constructed while an important attempt was made to determine the size of the Earth. Among the astronomers of Al Mamun and his successors one of the greatest was Ahmed ben Muhammed Al Fargani (afterwards known in the West as Alfraganus), whose *Elements of Astronomy* were translated into Latin in the twelfth century and contributed greatly to the revival of science in Europe.[1] Tabit ben Korra (826–901) was a most prolific writer and translator, but is chiefly known in the history of astronomy as a supporter of the erroneous idea of the oscillatory motion of the equinoxes. A younger contemporary of his, Muhammed Al Battani (died 929), was the most renowned of all the Arabian astronomers and became known in the West in the twelfth century (under the name of Albategnius) by the translation of the introduction to his tables.[2] Already in his time the power of the Caliphs had commenced to decline, and they soon lost all temporal power. The study of astronomy was, however, not influenced by this loss of patronage, as the Persian family of the Buyids, who in 946 obtained possession of the post of Amir-al-Omara (corresponding to the Frankish Major Domus) took over the *role* of patrons of science, so long and so honourably carried on by the Abbasid Caliphs. Sharaf al Daula built in 988 a new observatory in the garden of his palace, and among the astronomers who worked there was Muhammed Abu 'l Wefa al Buzjani (959-998), who wrote an *Almagest* in order to

1. First printed at Ferrara in 1493. See the edition of Golius, Amsterdam, 1669.

2. Translated by Plato of Tivoli. First Printed in 1537 after the book of Alfargani. Dreyer has used the edition of Bologna, 1645, and a new edition which is now being published by C. A. Nallino, of which the Arabic and a Latin translation of the text have already appeared (*Pubbl. d. R. Osservatorio di Brera in Milano*, No. 40, 1899-1903).

make the contents of Ptolemy's work accessible to the less learned. In the nineteenth century this book gave rise to a long controversy, which we shall presently consider somewhat in detail.

Western Countries under Islam

In the eleventh and twelfth centuries we do not find any names of conspicuous astronomers in Muhammedan Asia. But the western countries under Islam had in the meantime become ready to do their share of the work of keeping the mathematical sciences alive. In the Fatimite kingdom of Egypt Ali ben Abi Said Abderrahman ben Ahmed ben Jūnis, generally called Ibn Jūnis (died 1009), was distinguished both as an astronomer and a poet. At Cairo a liberally equipped observatory enabled him to verify the planetary theories which had once been developed in the neighbouring Alexandria. and in token of his gratitude to the reigning sovereign, Al Hakim, he named his work the Hakemite Tables.[1] We have to pass to the farthest west to find the next astronomer of mark in the person of Ibrahim Abu Ishak, known as Al Zarkali (in Europe afterwards called Arzachel). He was a native of Cordova, lived about 1029-1087, and edited planetary tables called the Toledo Tables.[2] In the following century we find two celebrated astronomers of Seville, Gabir ben Aflah, known as Geber (died 1145, often mistaken for the great alchemist, Gabir ben Haijan, in the eighth century),[3] and Nur ed-din al Betrūgi (Alpetragius), both of whom raised objections to the planetary theories of Ptolemy, though they failed to produce anything better of their own. Spanish astronomy continued to flourish for a while, although the power of the Arabs in the Peninsula was rapidly declining, and it produced in the thirteenth century a very remarkable man, who, although a Christian king, must be included in this account of Arabian astronomy,

1. Caussin has published an extract in vol. *vii* of the *Notices et Extraits des manuscrits (Le livre de la grande table Hakemite)*. Other Chapters, translated by the elder Sedillot but never published, are reviewed by Delambre, *Hist, de l'astr. du Moyen Age.*, p. 95 sqq.

2. Never published. Delambre, l. c. p 176, and Steinschneider, *Etudes sur Zarkali. Bullettino Boncompagni* T. *xx.* p. 1.

3 The word algebra has also sometimes erroneously been connected with his name.

as he owed all he knew about the science to the example and the teaching of Muhammedans and Jews. King Alfonso X, of Castille named el Sabio (1252-1284), followed the example of the Caliphs and called astronomers to his court to assist in the preparation of the renowned Alfonsine Tables.

With Alfonso the study of astronomy disappeared from Spain, but not before it had been revived in the East. In 1258 the still existing but shadowy Caliphate of Baghdad was swept away by the Mongol conqueror Hulagu Khan, grandson of Genghis Khan; but already in the following year this great warrior listened to the advice of his new vazier, Nasir ed-din al Tūsi (born at Tūs in Khorasan in 1201, died in 1274), and founded a great and magnificient observatory at Merāgha, in the north-west of Persia, In this observatory, which was furnished with a large number of instruments, partly of novel construction, Nasir ed-din and his assistants observed the planets diligently and produced after twelve years labour, the "Ilokhanic Tables," Among the astronomers of Merāgha seems to have been Juhanna Abu 'l Faraj, called Bar Hebrāyā, or the son of a Jew. He was a Christian, born in 1226 and from 1264, till his death in 1286 Maphrian or Primate of the Eastern Jacobites. He left a well-known chronicle and an astronomical work, both written in Syriac, as well as other writings.[1] The observatory at Merāgha had not a long life, and Asiatic astronomy had to wait a century and a half, until the grandson of another terrible conqueror erected another observatory. Ulug Begh, grandson of Tamerlan, drew learned men to Samarkand and built an observatory there about the year 1420, where new planetary tables and a new star catalogue, the first since Ptolemy's, were prepared. Ulug Begh died in 1449, he was the last great Asiatic protector of astronomy; but just as the Eastern countries saw the star of Urania setting, it was rising again for Europe.

In this review of Arabian astronomers we have only mentioned a few, omitting several names of distinction, whose

1 *Le livre de l' ascension de l' esprit sur la forme du ciel et de la terre.* Cours d' Astronomie redige en 1279 par Gregoire Aboulfarag, dit Bar Hebraeus, Publie par F. Nau, Paris, 1899-1900 (2 parts, Syriac and French). His chronicle is the chief authority for the fable about the burning of the Alexandrian Library by order of the Caliph Omar. For a very thorough refutation of this see Butler, *The Arab Conquest of Egypt*, Oxford, 1902 pp 401-426.

owners devoted themselves to other branches of astronomy. Though Europe owes a debt of gratitude to the Arabs for keeping alive the flame of science for many centuries and for taking observations, some of which are still of value, it cannot be denied that they left astronomy pretty much as they found it. They determined several important constants anew, but they did not make a single improvement in the planetary theories. It will therefore be sufficient to enumerate the improvements attempted and the opinions held by Arabian astronomers without keeping strictly to the chronological order, although we are here dealing with a period of about six hundred years and men belonging to very different nations, who had little in common except their religion and the language in which they wrote.

Figure of Earth

Turning first to the question of the figure of the Earth, we find a remarkable contrast between Europe and Asia. In the world under Islam there was an entire absence of that hostility to science which distinguished Europe during the first half of the Middle Ages. Though we learn from Kazwini's *Cosmography*[1] that some of the earlier Arabs believed the Earth to be shaped like a shield or a drum, still there is no record of any Arabian having been persecuted for asserting that the Earth is a sphere capable of being inhabited all over. Whether this was in consequence of the warriors of the Caliphs having carried their arms to the centre of France on one side and to the borders of China on the other while their merchants travelled southward to Mazambique and northward to the centre of Asia, is another question : anyhow, the fact of the Earth being a sphere of very small dimensions in comparison to the size of the universe was accepted without opposition by every Arabian scholar, and the very first scientific work undertaken after the rise of astronomy among them was a determination of the size of the Earth. It was carried out by order of the Caliph Al Mamun in the plain of Palmyra. According to the account given by Ibn Jūnis, the length of a degree was measured by two observers between Wamia and Tadmor and by two others in another locality, we are not told where. The first measure gave a degree

1. *Zakarija Ben Muhammed Ben Mahmūd El Kazwini's Kosmographie*, deutsch von H. Ethe, Leipzig, 1868, p. 295.

equal to 57, the second one equal to $56\frac{1}{4}$ Arabian miles of 4000 black cubits, and the approximate mean, $56\frac{2}{3}$ miles, was adopted as the final result, the circumference of the Earth being 20,400 miles and the diameter 6500 miles. Another report, by Ahmed ben Abdallah, called Habash, an astronomer under Al Mamun (quoted by Ibn Jūnis), states that a party of observers (no names given) proceeded along the plain of Sinjar until they found a difference in meridian altitudes, measured the same day, equal to one degree, while the distance travelled over was found to be $56\frac{1}{4}$ miles[1]. Probably two different determinations were made. If the "black cubit" is the Egyptian and Babylonian cubit of 525 mm.[2], the mile would be=2100 m. and $56\frac{2}{3}$ miles=119,000 meters, rather a large result.

The doctrine of the spherical earth remained undisputed in the Muhammedan learned world, though the curious error of assuming that the level of the sea was higher on some parts of the Earth than on others appears to have found some adherents among Arabian writers as well as in Europe.[3] We may, therefore, at once pass on to the motions of the heavenly bodies. Al Battani determined the longitude of the Sun's apogee and found it=82° or $16^{\circ} 47^{1}$ more than Ptolemy had given. As he believed

1. Caussin, *Not. et Extraits.* vii. pp. 94-96; Delambre, *Hist. de l'astr du Moyen Age.* pp. 78 and 97; Shems ed-din, *Manuel de la cosmographie*, traduit par Mehren, Copenhague. 1874 p. 6. Suter, p. 209, mentions a third report (from Ibn Challikān's *Biographical Dictionary*), according to which the sons of Musa first measured in the plain of Sinjar and afterwards as a test at Kūfa, by order of Al Mamun. The eldest of the sons of Musa died 41 years after Al Mamun, and the names of the observers in the first report are different, so that the third report is not to be relied on. Al Fargani merely gives $56\frac{2}{3}$ miles as the result of Al Mamun. According to Shah Cholgii *Astronomica . . . . studio et opera Ioh. Gravii*, London, 1652, p. 95, Ala ed-din Al Kūsgi (one of the Ulug Begh's astronomers) gives the circumference of the earth=8000 parasangs. As a persian parasang =30 stadia (Hultsch; *Griech u. Rom. Metrologie.* p. 476) this would seem to be the value of Posidonius, 240,000 stadia. Kazwini (p. 298) gives the circumference=6800 parasangs on the authority of Al Berūni.
2. Hultsch p. 390.
3. It deserves to be mentioned that Shems ed-din of Damascus (1256-1327) explains the great Preponderance of dry land in the northern hemisphere by the attraction of the Sun on the water, which is the greatest when the Sun is in perigee, at which time it is nearly at its greatest south declination. That this accumulation of water would not be a permanent one does not occur to him (*Cosmographie*, p. 4).

that Ptolemy's value had been found by himself,[1] and as he adopted 54″ (or 1° in 66 years) as the annual amount of precession, there remained (assuming that 760 years had passed since the time of Ptolemy) an outstanding error of 79″—54″=25″ per annum. In reality the annual motion of the solar apsides is 11½″; still we may say that the discovery of this motion is due to Al Battani, though he did not announce it as such; in fact he merely gives his own value as an improvement on that of Ptolemy. Even Ibn Jūnis (who found 86° 10′) did not suspect that the apogee was steadily moving but merely says that it must be corrected for precession (1° in 70 years), and remarks that the longitude of the apogee is very difficult to determine accurately.[2] On the other hand, Al Zarkali found a smaller value, 77° 50′ and as he also found a smaller value of the eccentricity he thought it necessary to let the centre of the Sun's eccentric orbit describe a smaller circle, after the example set by Ptolemy in the case of Mercury.[3] The inclination of the ecliptic which the Greeks had found—23° 51 20″ was by the astronomers of Al Mamun found—23° 33′ (in 830), by Al Battani (in 879), and by Ibn Jūnis 23° 35′[4]. When Al Zarkali found 23° 33',he, and afterwards Abu 'l Hassan Ali of Morocco, concluded that the obliquity oscillated between 23° 53 and 23° 33', an idea to which the prevailing belief in the "trepidation" of the equinoxes lent countenance.[5]

Moon and its orbit

If we now turn to the Moon, we do not find that the Arabs made any advance on Ptolemy. Several of them noticed that the inclination of the lunar orbit was not exactly 5°, as stated by Hipparchus. Thus, Abu 'l Hassan Ali ben Amagiur early in the tenth century says that he had often measured the greatest latitude of the Moon and found results greater than that

1. *Scient. Stell.* Cap. xxviii. Bologna, 1645, p. 72; Nallino. p. 44. At the end of Cap. xlv. he says the apogees of the Sun and Venus are both in 82° 14,′ and Ibn Jūnis also gives 82° 14′ as the value found by Al Battani (Caussin, p. 154).
2. Caussin, pp. 232 and 238. Abu'l Faraj gives 89° 28′ for the year 1279 (p. 22).
3. Sedillot, *Prolegomenes aux tables astron. d' Olough Beg* (1847), pp. lxxx-lxxxii. Riccioli, *Almag. Novum*, I. p. 157.
4. Caussin. p. 56. For A.D. 900 Newcomb gives 23° 34′ 54″, with a diminution of 46″ per century, so that the Arabian astronomers erred less then 1′.
5. Aboul Hassan Ali, *Traite des Instruments astron. des Arabes*; T.I.p. 175; Sedillot, *Memoire sur les instr. astr. des Arabes*, p. 32.

of Hipparchus, but varying considerably and irregularly. Ibn Jūnis, who quotes this, adds that he has himself found 5° 3′ or 5° 8′, while other observers are said to have found from 4° 58′ to 4° 45′.[1] Want of perseverance and of accurate instruments caused them to miss a remarkable discovery, that of the variation of the lunar inclination.

Abu 'l Wefa and his Almagest

But an even more remarkable discovery has been claimed for an Arabian astronomer. In 1836 the younger Sedillot announced that he had found the third inequality, the variation, distinctly announced in Abu 'l Wefa's *Almagest*. A fierce controversy raged for a number of years as to the reality of this discovery, Sedillot alone defending his hero with desperate energy and refusing to listen to any arguments, while Biot, Libri and others as strenuously maintained that Abu 'l Wefa simply spoke of the second part of the evection, the prosneusis of Ptolemy. The fight had died out when, in 1892, Chasles suddenly took up the cudgels for Sedillot and pointed out what seemed to him to be some contradictions in Ptolemy's statement.[2] Nobody answered this until Bertrand did so in 1871; he called attention to several inaccuracies in the text of Abu 'l Wefa as we possess it now, and also showed that Abu 'l Wefa did not add his "mohazat" to the prosneusis, the latter not being included in his "second anomaly."[3] It is unnecessary to enter into a more detailed account of the controversy; but to show that any weapon was considered good enough with which to defend Abu 'l Wefa, it may be mentioned that Sedillot and Chasles tried to prove that Tycho Brahe must have copied his discovery from Abu 'l Wefa, because he calls it *hypothesis redintegrata*. Tycho used this same phrase in speaking of his own planetary system, which he most emphatically claimed as

1. Sedillot, *Prolegomenes*. p. *xxxviii*. *Materiaux pour servir a l' hist. des sciences chez les Grecs et les Orientaux*, T. I. p. 283. The sons of Mūsā ben Sakir (about 850) seem to have been the first to find a value differing from that of the ancients. Abraham ben Chija, a Jewish writer who lived about A. D. 1100 says that Ptolemy found 5°, but that according to the opinion of the Ishmaelites it is 4½° (*Sphaera mundi*. Basle. 1546 p. 102).
2. *Lettre a M. Sedillot sur la question de la variation lunaire*. Paris, 1862, 15 pp. 4° and *Comptes Rendus*, vol. 54, p. 1002.
3. *Comptes Rendus*. vol. 73, pp. 581, 756, 889 ; *Journal des Savants*. 11 Oct. 1871.

an original discovery, and which he vigorously defended against other claimants. In future it will be hopeless for anybody to claim the discovery for Abu 'l Wefa as the matter has now been thoroughly sifted, both by mathematicians and orientalists.

The *Almagest* of Abu 'l Wefa has never been published in full, but there are three translations of the chapters in question,[1] which only differ in some trivial points. In no part of the book does he make any advance on Ptolemy or claim to have made any new discovery, and in speaking of three inequalities he merely does what the other Arabian astronomers do.[2] He begins by describing the first (equation of the centre) and the second (evection) and states when they reach their maxima. He then says that we have found[3] a third inequality, which takes place when the centre of the epicycle is between the apogee and the perigee of the eccentric, and which reaches its maximum when the Moon is about a *tathlith* or a *tasdis* from the Sun, while it is insensible in syzygy and quadrature. The maximum is $\frac{3}{4}°$. He explains that this is caused by a deviation of the line or apsides of the epicycle, and he describes quite correctly the construction adopted by Ptolemy (whose name he does not mention), letting the line of apsides be directed, not to the Earth but to another point on the line of apsides of the eccentric. It is difficult for an unbiassed reader to understand how anyone could fail to see that Abu 'l Wefa is simply copying Ptolemy. Sedillot maintained that the words *tathlith* and *tasdis* mean the octants (where the variation reaches its maximum); but every other orientalist who has expressed an opinion, states that by their roots the words correspond to the numbers 6 and 3, in other words, to elongations 60° and 120° from the Sun. This is in accordance with

1. By Reinaud, Munk, and de Slane(for Biot)in the *Journal des Savants*, March, 1845 (14 pp. the whole section on the Moon) ; by Sedillot, *Materiaux*, i. pp. 45--49 ; and by Carra de Vaux, "L' almageste d' Abū 'l Wefa Albūzdjani," *Journal asiatique*, 8° Serie, T. *xix*. (1892), pp. 408--471 (translation on pp. 443-44). Most of the chapters on the planets are lost.

2. The unknown author of a short resume of astronomy (in the *Bibl. Nationale*) even calls the inequality of prosneusis the first equation (Carra de Vaux, l.c. p. 460). This is not unreasonable, since the equation of the centre must be taken from the lunar tables, using as argument not the mean anomaly but the latter corrected for the effect of the prosneusis.

3. He uses exactly the same expression when speaking of the first and second inequalities.

facts, as Biot has shown from the Ptolemy's numerical data that the deviation of the line of apsides reaches its maximum value of $\pm$ 13° 8′ .9 in elongations 90° $\mp$ 32° 57′.5.[1] But it must be acknowledged that the words in question are also used very vaguely, e. g. by Abu 'l Wefa himself, who says that the velocity of the superior planets after emerging from the Sun's rays diminishes gradually till their distance from the Sun is about a *tathlith*, when they become stationary. It looks almost as if these words might be used to denote any elongation outside syzygy and quadrature.[2]

If Abu 'l Wefa had made a new discovery, we should have expected later Arabian astronomers to have alluded to it. But not one of them gives anything but interpretations of the lunar theory of Ptolemy, and in expressions very similar to those employed by Abu 'l Wefa. Attention was at once called to this fact, and Isaac Israeli of Toledo (about 1310) and Geber of Seville were quoted as examples,[3] though it would, of course, have been quite possible for these two writers to have remained ignorant of whatever progress astronomy might have made in the school of Baghdad. But this objection does not apply to Nasir ed-din al Tūsi, in whose review of the Almagest and Memorial of Astronomy the inequalities known to Ptolemy and no others, are described and credited to Ptolemy[4]; not to Mahamud al Jagmini (about 1300) , who wrote a compendium (*mulachchas*)

1. *Journal des Savants*, 1843, p. 701 ("Sur un traite arabe relatif a l' astronomie," Reprint, p. 47). This deviation does not represent the amount of the correction to the Moon's place as seen from the Earth, so that there is not any contradiction in Ptolemy's account.

2. Carra de Vaux, l. c. p. 466. The Arabs had no word for "octants." Nasir-ed-din on one occasion wants to mention them, and has to call them "the points midway between syzygy and quadrature."

3. Isaac Israeli repeatedly speaks of these inequalities discovered by Ptolemy, two of which are not found at conjunction and opposition. *Liber Jesod, Olam seu Fundamentum Mundi auctore R. Isaac Israeli Hispano*, section III. ch. 8 and sect. v. ch. 16, Part I. p. xxiv Part II. p. xxxi (Berlin, 1848 and 1846 ; this publication is not mentioned by Carra de Vaux).

4. C. de Vaux, "Les spheres celestes selon Nasir Eddin Attūsi", Appendix to P. Tannery's *Recherches sur l' astr. anc.* p. 342, and *Journ. asiat.* 1892, p. 459 : "The third anomaly is that of the prosneusis ; it is called the equation of the proper motion" (i.e. of the motion on the epicycle).

of astronomy.[1] Nor can any objection be raised to Abu'l Faraj (Bar Hebraeus), and it would be impossible to explain more clearly than he does the effect of the prosneusis. He says: " The third inequality is the angle formed at the centre of the epicycle by two lines which are drawn, one from the centre of the universe and the other from the point called the prosneusis, at the end of which is the apogee of the epicycle, at which commences the proper motion, and which is called the mean apogee. The apogee which is at the end of the line drawn from the centre of the universe is called the apparent one. The point proseneusis is on the side of the perigee of the eccentric, 10 parts 17 minutes from the centre of the world[2] which is itself at the same distance from the centre of eccentric. The maximum value of this angle is 13 parts 9 minutes when the Moon is a crescent or ⅔ gibbous, that is, near the hexagon or trigon with the Sun. In fact, when the epicycle is four or eight signs distant from the apogee of the eccentric, the Sun is itself two or four signs distant from [the centre of the epicycle] because it is half way between this centre and the apogee. In the tables, this inequality of the two apogees is called the first angle and is included in the motion of the centre."[3] While this describes the construction of Ptolemy as clrealy as possible, at the same time the agreement of the account with that of Abu' l Wefa is perfect. Abu'l Faraj even (like Nasir ed-din) describes as a fourth inequality in longitude that caused by the motion along an orbit inclined to the ecliptic, so that he would not have neglected to describe the variation, if it had been found by an astronomer of Baghdad. We may add that the Jewish writer Abraham ben Chija (A. D. 1100), in his *Sphaera Mundi*, also describes the "aberration" of the apside of the epicycle, chiefly "in sexta et tertia parte mensis."[4]

1. Translated by Rudloff and Hochheim, *Zeitschrift der Deutschen Morgenland Ges.* XLVII pp. 213—275. He describes (p. 249) how the line of apsides is directed to a point called "the corresponding point," and gives its position correctly. The inequality he calls the deviation.
2. Nasir ed-din gives $10^p\ 9^r$.
3. *Le livre de l' ascension*, & c. T. II. PP. 29-30. Two codices add after the word prosneusis : "This is the point mohazat."
4. *Sphaera Mundi* (1546, ed. Schreckenfuchs), p. 75. Munster's commentary to the Hebrew text (p. 116) has "cum centrum est in sextili aut trino aspectu [id est, quando abest a sole duobus signis aut quatuor]" ; the words in brackets are not in the Hebrew original. The words "sixth" and "third" are unmistakable (shithith and shelishith). Apparently no one has hitherto thought of consulting Abraham ben Chija.

Abu 'l Wefa and Ptolemy

Therefore, Abu 'l Wefa did not know a single thing about the motion of the Moon which he had not borrowed from Ptolemy. But the prosneusis of Ptolemy is not the variation discovered by Tycho Brahe. The latter depends solely on the elongation of the Moon from the Sun, as it is $= +39'.5 \sin 2\varepsilon$, while it is beyond the power of mortal man to express the effect of the prosneusis without the anomaly. Ptolemy's exprssion for all the inequalities in longitude assumed by him, when developed analytically, found to contain, in addition to terms represening the equation of the centre and the evection, the latter being

$$+1°19'.5 \sin (2\varepsilon - m),$$

a very considerable term

$$+17.8 \sin 2\varepsilon [\cos (2\varepsilon + m) + 2 \cos (2\varepsilon - m)],$$

where ε is the elongation and m the mean anomaly.[1]

Obviously this term has nothing in common with the variation, except that it disappears in the syzygies and quadratures. Tycho Brahe did not hang his new term on to the unaltered lunar theory of Ptolemy, and by doing that we should in fact only spoil the latter and make its maximum error rise to more than a degree.[2] Owing to the insufficiency of the observations at his disposal, Ptolemy could only perceive that there was some outstanding inequality after allowing for the evection, only appearing outside the syzygies and quadratures, but he was neither able to find the law which governed the phenomenon, nor was he aware what a large quantity it represented; he could only tinker up his constructions a little, and in this he was most faithfully followed by the Arabs, who added nothing to what he had done and left it to the reviver of practical astronomy to discover the third lunar inequality.

Al Fargani and others on Planets

Passing to the five planets, we find that, generally speaking, very few attempts were made to improve the work of Ptolemy. But the Arabs were not content to consider the Ptolemaic system

P. Tannery, *Recherches*, p. 213. Another expansion of Ptolemy's lunar inequalities in a series was given by Biot, *Journal des Savants*, 1843, p. 703 (Reprint, p. 49).

P. Kempf, *Untersuchungen uber die Ptolemaische Theorie der Mondbewegung*, Berlin, 1878 (Inaug. Diss.), p. 37.

merely as a geometrical aid to computation; they required a real and physically true system of the world, and had therefore to assume solid crystal spheres after the manner of Aristotle. Above the Moon is the Alacir, the fifth essence, which is devoid of lightness and heaviness, and is not perceptible to the human senses; of this substance the spheres and planets are formed.[1] Already in the book of Al Fargani we find the principle adopted which we have seen dates from the fifth century (Proklus) and which became universally accepted in the Middle Ages, that the greatest distance of a planet is equal to the smallest of the planet immediately above it, so that there are no empty spaces between the spheres.[2] The semidiameter of the Earth is by Al Fargani given as 3250 miles, which corresponds very nearly to Al Mamun's $56\frac{2}{3}$ miles to a degree, if we put $\pi = \frac{22}{7}$. Starting from Ptolemy's distances of

Greatest Distance of	Al Fargani	Al Battani	Abu 'l Faraj[3]
Moon	$64\frac{1}{6}$	$64\frac{1}{6}$	$64\frac{1}{6}$
Mercury	167	166	174
Venus	1,120	1,079	1,160
Sun	1,220	1,146[4]	1,260
Mars	8,876	8,022	8,820
Jupiter	14,405	12,924[5]	14,259
Saturn	20,110	18,094	19,963

the Moon and the Sun, it was easy to express the other distances in semidiameters of the Earth, the ratios between the greatest and

1. Al Battani, cap. 50 (p. 195).
2. Al Fargani, cap. 21 (ed. Golius, p. 80). Much later, Maurolycus in his *Cosmographia* (Venice, 1543, f, 20a) proves that Mercury and Venus must be below the Sun, by pointing out that there would otherwise be a large vacant space between the Sun and the Moon.
3. pp. 189-191.
4. So in Nallino's ed. (Milan, 1903 p. 121) the ed. of 1645 has 1176.
5. The ed. of 1645 has 12, 420; obviously an error, as the ratio of greatest to smallest distance is given as 37:23 for Saturn 7:5 (misprinted 7:2), or "quantitas unius et duarum quintarum ad unum" (p. 199). Nallino's ed (Milan 1903) has 12,924. Abraham ben Chija has 12,400.

smallest distances being in substantial agreement with the theory of Ptolemy. Al Battani also gives a similar set of figures, though with some slight differences. He does not mention peculiar treatment given by Ptolemy to the theory of Mercury. The above table gives the distance expressed in semidiameters of the Earth.

Al Kusgi and diameters of planets

Al Kūsgi, one of the astronomers of Ulug Begh, gives a list of the semidiameters of the "concavities" of the planetary spheres (i.e. the smallest distances of the spheres) expressed in parasangs, the diameter of the Earth being 2,545 parasangs.[1] Expressed in semidiameters of the Earth, the figures turn out somewhat differrent from those given above, e.g. the smallest distance of the Sun being 1,452 and the greatest of Saturn 26,332, but he does not supply any means of making out how these figures were found.

Before leaving this subject, we shall also give the diameters of the planets according to Al Fargani, as they became known in Europe at an early date and were quoted by Roger Bacon and others.[2] With trifling variations the same values are given by Al Battani, Abu 'l Faraj, and Abraham ben Chija.

	Apparent Diameter	True Diameter (Earth's=1)
Moon in apogee	$31\frac{2}{5}'$ ...	1 : $3\frac{2}{5}$
Mercury, mean dist.	$\frac{1}{15}$ of Sun's ...	$\frac{1}{28}$
Venus „ „	$\frac{1}{10}$ „ ...	1 : $3\frac{1}{3}$
Sun „ „	$31\frac{2}{5}'$ ...	$5\frac{1}{2}$
Mars „ „	$\frac{1}{20}$ of Sun's ...	$1\frac{1}{6}$
Jupiter „ „	$\frac{1}{12}$ of Sun's ...	$4\frac{1}{2} + \frac{1}{16}$
Saturn „ „	$\frac{1}{18}$ „ ...	$4\frac{1}{2}$

Al Kazwini, Abu'l Faraj and Al-Jagmini on Excentric Spheres of the Sun

The system of the spheres is set forth in greatest detail in three treatises of later date, the cosmograpy of Zakarija ben Muhammed ben Mahmud al Kazwini (about 1275), the astronomy

1. *Astronomica Shah Cholgii*, pp. 95-97.
2. There are some slight differences between the figures given in the various editions (J.L.E. Dreyer has compared those of 1493, 1546, and 1669), but those given above agree with the cubic contents according to Al Fargani. The figures of Kazwini seem to have been greatly corrupted.

of Abu 'l Faraj, written in 1279, and that of Mahmud ibn Muhammed ibn Omar al Jagmini, whose date and nationality are equally uncertain, but who probably wrote in the thirteenth or fourteenth century. We find in these text-books an elaborate system of spheres designed to account for every particular of planetary motion, in perfect agreement with each other as to the general arrangement of the spheres, and offering nothing new as to lunar or planetary theory. The accompanying figures (taken from Jagmini) will illustrate the ideas better than a lengthy description.[1] The Sun is a solid sperical body, fitting between two excentric spherical surfaces, which touch two other surfaces, in the

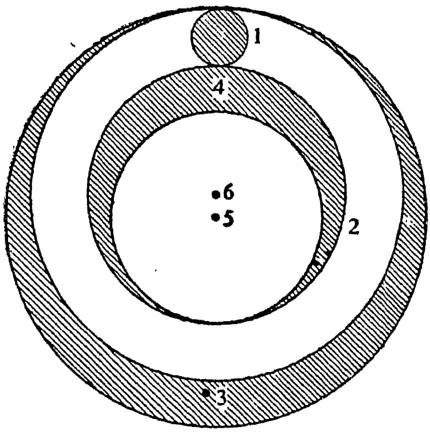


Fig. 1.—Planetary motions and system of spheres.

1. The Sun. 2. Excentric sphere. 3. The surrounding spheres. 4. The complement of the surrounding sphere. 5. Centre of the world. 6. Centre of the excentric sphere.

common centre of which the Earth is situated, and which between them enclose a space (or intersphere, as Abu 'l Faraj calls it), named by Jagmini al-mumattal, or the equably turning sphere, which has the same motion from west to east as the fixed stars, i.e. precession. The spheres of the three outer planets and Venus are arranged on the same plan, except that the place of the body of the Sun is taken hy the epicycle-sphere of each planet, to the inner surface of which the planet (a solid spherical body) is attached or (as Abu 'l Faraj says[2]) "fixed like a pearl on a ring, touching the

1. Al Kusgi gives very similar diagrams of the spheres of the Saturn, Mercury, and the Moon.

2. Precession is supposed to be included in this, "the first motion." The second

(Continued on next page)

surface in one point." The axis of the excentric sphere is inclined to that of the mumaṭṭal sphere, which causes the motion in latitude. The lunar system comprises an additional sphere outside the others, the centre of which coincides with the centre of the world, and which is called *al-gauzahar*, signifying the cosntellation Draco, as this sphere provides for the revolution of the lunar nodes ("the head and tail of the dragon") round the zodiac. The inner one of the two concentric spherical surfaces, between which the excentric sphere lies, surrounds immediately the fire sphere of the Earth. The system of Mercury is more complicated, as a space had to be provided for the revolution of the centre of the

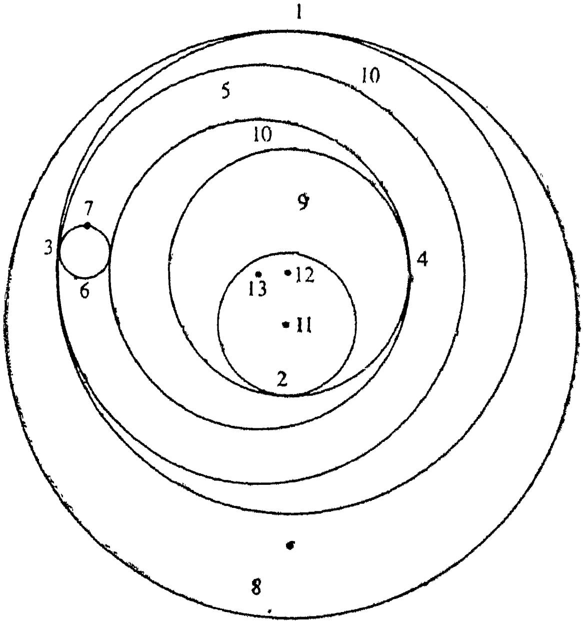


Fig. 2.—Spheres of Mercury

1. Upper Apsis. 2. Lower Apsis. Upper Apsis of deferent sphere. 5. Deferent sphere. 4 Lower Apsis of deferent sphere. 6. Epicycle. 7. Mercury. 8. Surrounding complement. 9. Surrounded part of Mumaṭṭal sphere. 10. Mūdir sphere. 11. Centre of the world. 12. Centre of Mūdir. 13. Centre of deferent sphere.

(Continued from previous page)

one is that of the concentric oblique intersphere (called the mail sphere or the sphæra deflectens) round the centre of the world, 11°9′ per day, by which amount the lunar apogee moves towards the west. The third motion is that of the excentric, carrying the centre of the epicycle 24°22′ towards the east. The fourth is the motion on the epicycle. Abu 'l Faraj, p. 27.

excentric sphere. The figure shows the excentric sphere enclosed in a sphere, *al-mūdir* or the turning one, which allows the upper apsis or apogee of the excentric or deferent sphere (3 in the figure) to move right round the outer surface of the *mūdir*. The inner surface of the mumaṭṭal sphere immediately surrounds the *gauzahar* sphere of the Moon.

It was a necessary consequence of the large solar parallax of 3' accepted by Ptolemy, that Mercury and Venus must be very near the Earth, since they are assumed to be nearer than the Sun. Thus Abraham ben Chija says that the shadow or the Earth extends beyond the orbit of Mercury but does not reach that of Venus.[1] Ptolemy never mentions the parallaxes of Mercury and Venus, as to which nothing was known, though they ought, of course, to be greater than 3'. But on the assumption that the smallest distance of Mercury is equal to the distance of the Moon at apogee, the parallax of Mercury ought to rise to 54', which must have been felt to be too large a quantity, though it does not seem to have struck Al Battani as anything surprising, perhaps because Mercury cannot be seen when in inferior conjunction. It may have been this necessarily large parallax of Mercury, which induced Ibn Jūnis (without any explanation) to reduce the solar parallax from 3 to 2', or rather to 1' 57".[2] Geber[3] blames Ptolemy for having said that the parallaxes of the planets are insensible, and remarks that he ought, therefore, logically to have placed Venus and Mercury above the Sun. He takes great pains to show that Venus may be exactly on the line joining the Sun and the Earth. Indeed, Geber neglects no opportunity of criticising Ptolemy's methods of finding the elements of the orbits,[4] and he is generally very unjust to him but he does not venture to

1. *Sphaera mundi*, ed. Osw. Schreckenfuchs, Basle, 1546 pp. 84, 86.

2. Unpublished chapters of Ibn Jūnis, reviewed by Delambre, *Hist. de l'astr. du Moyen Age*. p. 101.

3. *Instrumentum primi mobilis a P. Apiano. Accedunt ijs Gebri filii Affla Hispalensis. . . libri* IX. *de astronomia*, Norimbergæ, 1534, fol. (Introd. p. 3 and lib. VII. p. 104).

4. See the long indictment on pp. 2-3 of his introduction. He blames Ptolemy among other things for assuming that the centre of the deferent is half-way between the centres of the zodiac and of the equant, while he himself deduces this from the movements.

substitute any other system and does not object to the general principles of the Ptolemaic system.[1]

Three great names :
Ibn Badja, Ibn Tofeil (Abubacer) and Abu Welid (Averroes)

Geber's attempts to pick holes in the work of Ptolemy were, perhaps, not unconnected with the rapid rise of Aristotelean philosophy in Spain in the twelfth century, which, though not destined to last long, nevertheless exercised a considerable influence on the spread of knowledge of Aristotle in the Christian world, while it cast a halo round the Caliphate of Cordova, which at that time, under the enlightened rule of the Almohades, seemed to have reestablished the glory of the best days of the Moslem world. Three names are specially associated with this movement :

(i) Abu Bekr Muhammed Ibn Jahya al Sayeg, called Ibn Badja (of Saragossa, died 1139), known as Avempace among the Scholastics ;

(ii) his pupil Muhammed ben Abdelmelik Ibn Tofeil (of Granada, died 1185-1186), called Abubacer by the Scholastics ;

(iii) and finally the greatest philosopher of Islam, Ibn Rosd Abu Welid, known as Averroes (1126-1198).

In studying Aristotle they laid special stress on his scientific works, and did not, like their Christian successors, think of little but dialectics. The acceptance of the system of homocentric spheres or some modification of it must, therefore, have seemed a necessity to the Arabian philosophers and this, of course, led them to reject the theory of epicycles.. The little we know of the opinions of Ibn Badja on this subject is found in the famous work *The Guide of the Perplexed* of the great Jewish scholar Moses ben Maimun of Cordova, better known as Maimonides, who tells us that he had his information from a pupil of Ibn Badja. Like Geber (with whose son he had been familiar), Maimonides doubted that Mercury and Venus were nearer than

1. Copernicus possessed a copy of Geber's book; which is now in the University library at Upsala. On the title page, after the author's name, he has written : "Egregii, Calumiatoris Ptolemaei," while a number of marginal notes show that he has read the book carefully. Curtze, *Mittheilungen des Coppernicus Vereins*, I, p. 37.

the Sun, though he would not venture to say how they actually moved.[1] But what is more important, he declared the motion of a planet on an epicycle to be contrary to physical principles, because there are only three motions possible in this world : around its centre, or towards it, or away from it; while he also maintained that according to Aristotle circular motion can only take place round a real, central body.[2] Though Aristotle in reality did not object to epicyclic motion with a mathematical point as centre, for the simple reason that it had not been proposed when he wrote, while, as we have seen, his moving principle had nothing to do with the centre of motion, it is easy to see that Ibn Badja's real difficulty was the same which afterwards produced so many obstacles to the advance of science in Europe : whatever could not be found in Aristotle's book must be unworthy of notice. According to Maimonides (who, however, makes the reservation that he had not heard it from disciples), Ibn Badja constructed a system of his own, in which he only admitted excentric circles but no epicycles. We are not given any particulars as to this system but there can hardly be any doubt that its author confined himself to generalities and did not attempt to represent phenomena like the lunar inequalities by it. Maimonides remarks that there is nothing gained by Ibn Badja's reform, since the excentric hypothesis is as objectionable as the epicyclic one, as it also supposes motion round an imaginary point outside the centre of the Earth. The centre of the excentric, on which the Sun is supposed to move, is outside the convexity of the lunar sphere and inside the concavity of that of Saturn's excentric is between the spheres of Mars and Jupiter. He adds that the revolution of a number of concentric spheres around a common axis is conceivable, but not the revolution round different axes inclined to each other, as the spheres would disturb each other unless there are other spherical bodies between them. This attempt to revive and modify the system of (movable ?) excentrics did, therefore, not mend matters.[3]

1. *Rabbi Mosis Majemonidis Liber . . . . Doctor Perplexorum.* Basileæ, 1629, Pars II. cap. IX.

2. Ibid., Pars II. cap. XXIV.

3. Maimonides also remarks (in the same chapter) that the supposed inclinations of Mercury and Venus in the Ptolemaic system are difficult or impossible to comprehend or imagine as really existing. Therefore, if what

(Continued on next page)

Ibn Tofeil

Ibn Tofeil, the second of the three Moslem philosophers of Spain, vizier and physician at the court of Jusuf ben Abd el Mumin of Morocco, seems to have walked in the footsteps of his master ; but the only extant work of his, a kind of religious mystic romance about the emancipation of a soul from the trammels of this material world, does not give any clue to his ideas as to the planetary system. But Averroes, who also objected to the excentrics and epicycles says in his commentary to Aristotle's *Metaphysics* that Ibn Tofeil possessed on this subject excellent theories [2], and Ibn Tofeil's pupil, the astronomer Al Betrugi, in the introduction to his theory of the planets, says of him : "You know that the illustrious judge Abu Bekar Ibn Tofeil told us that he had found an astronomical system and principles of the various movements different from those laid down by Ptolemy and without admitting either excentrics or epicycles, and with this system all the motions are represented without error." Ibn Tofeil was therefore probably the real author of the fairly elaborate system, which his pupil worked out and handed down to us in a work on the planets, which was translated into Hebrew in the following century and from that again into Latin, and published in 1531 [3].

The object of this system was to explain the constitution of the universe as it really is, and not merely to represent the motions of the planets geometrically, so as to be able to foretell their places in the heavens at any time ; and the author (be he Ibn Tofeil or Al Betrugi alias Alpetragius) specially disclaims any intention of testing the theory by comparing it with observations

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(Continued from previous page)

Aristotle says is true, there is neither epicycle nor excentric, and everything turns round the centre of the Earth.

2. Munk ; *Melanges de philosophie juive et arabe*. Paris, 1859, p. 412.

3. *Alpetragii Arabi Planetarum theorica phisicis rationibus probata, nuperrime latinis litteris mandata a Calo Calonymos, Hebreo Neapolitano*, Venice 1531, 28 ff. folio (published with Sacrobosco's *Sphaera*). A translation by the famous Micheal Scot has never been printed, but is still extant in Paris (Munk, *Melanges*, p. 519). The principle of the system is described by Isaac Israeli, who, however, does not mention the author's name (*Liber Jesod Olam*, II. 9. Part I. p. XI

or of accounting for minor details of the motions.[1] The leading idea is that of the homocentric spheres, each star being attached to a sphere, and the motive power is the ninth sphere, the sphere outside that of the fixed stars. The Spanish philosopher ought, therefore, to have been content with the system of Eudoxus or its modification by Aristotle (whom he never mentions by name, but only as "the sage"), but unfortunately he became possessed with the notion that the prime mover must everywhere produce only a motion from east to west, and he had, therefore, to reject the independent motion of the planets from west to east, and revert to the old Ionian idea that the seven planets merely perform the daily revolution with a speed slightly slower than that of the fixed stars. The true speed of the *primum mobile* is a little faster than this ; the eighth sphere performs a revolution in a slightly longer period (24 hours), and the effect of the prime mover is gradually weakened more and more, with increasing distance, until we find the sphere of the Moon, being furthest from the prime mover, taking nearly twenty-five hours to complete a revolution. This was the old primitive Ionian idea, but Al Betrugi (or his teacher) saw that this was not sufficient, as not only is the pole of the ecliptic different from that of the equator, which prevents the planets from moving in closed orbits, but the planets do not even keep at the same distance from the pole of the ecliptic but have each their motion in latitude, as well as variable velocity in longitude ; and all this had yet to be accounted for. The ninth sphere has but one motion, but the eighth has two, that in longitude (precession) and another which is caused by the pole of the ecliptic describing a small circle round a mean position, thereby producing the supposed oscillation or trepidation of the equinoxes.[2] Similarly, the pole of each planet describes a small circle round a mean position (i. e. the pole of the ecliptic), thereby producing inequalities in longitude and motion in laritude[3] Whenever the actual orbit-pole of a planet is on the parallel of the mean pole, it is obvious that the planet will perform its daily revolution with its mean velocity, while the velocity is increased or lessened when the actual pole is respectively at ts minimum or maximum distance from the pole of the heavens

1. Fol. 8 b. 2. Fol. 9 b.

3. Fol. 14 b;. sq.

(the motion of the pole of the orbit being added to or subtracted from the motion of the planet), so that the epicycle is hereby rendered superfluous. The lengths of the radii of these small circles are not given, except in the case of Saturn, where the radius is 3° 3',[1] while the mean pole of the moon is 5° (the inclination of the lunar orbit) distant from the pole of the ecliptic,[2] and the small circle is so exceedingly small as to produce no retrograde motion, which is also the case with the Sun. The periods of the poles of the outer planets are given by the following figures Saturn makes 57 revolutions in 59 years and $1\frac{1}{2}+\frac{1}{4}$ days, in which period the mean pole lags behind 2 revolutions $1\frac{4}{5}°+\frac{3}{5}°$. Jupiter makes 65 revolutions in 71 years, the mean pole lagging behind 6 revolutions. Mars makes 37 revolutions in 79 years and $3\frac{1}{6}+\frac{1}{15}$ days, the pole lagging behind 42 revolutions and $3\frac{1}{7}°$[3].

In other words, the motion on these small circles are completed in the synodic periods of planets. Similarly, the pole of Venus makes 5 revolutions in the 8 years less $2\frac{1}{4}d+\frac{1}{20}$, lagging $1\frac{3}{8}$ revolutions in one year ; and Mercury 145 revolutions in 46 years and $1\frac{1}{30}d$[4]. It is curious that Alpetragius alters the order of the planets, placing Venus between Mars and the Sun, because the defectus (lagging) of Venus smaller than that of the Sun.[5] He also says that nobody has given any valid reason for accepting the usually assumed order of the planets, and that Ptolemy is wrong in stating that Mercury and Venus are never exactly in a line with the Sun (a remark already made by Geber) ; and as they shine by their own light they would not appear as dark spots, if passing between us and the Sun. That they do not receive their light from the Sun is proved, he thinks, by the fact that they never appear crescent-shaped.[6]

There is no need to dwell any longer on this quaint theory

1. Fol. 16 a.

2. Fol. 25 a.

3. Fol. 16 a, 18 a, 19 b.

4. Fol. 21 b, 24 b.

5. "Nam reperimus defectum eius primum minorem defectu orbis solis et maiorem defectu orbis martis, et sequitur juxta radices nostras ut sit inter eos ambos."

6. Fol. 21 a

of spiral motion, as it has been rather improperly called.[1] It represented a retrograde step of exceedingly great magnitude, totally unjustified as the theory could not seriously pretend to be superior to the Ptolemaic system, which had only become so very simple if one was content with representing only the principal phenomena. We are told by the Jewish astronomer Isaac Israeli of Toledo, that the new system made a great sensation, but that it was not sufficiently worked out to be taken seriously, and that the system of Ptolemy, founded on the most rigorous calculations, could not be superseded by it.[2] Another Jewish author, Levi ben Gerson, in a work written in 1328, entered into a lengthy refutation of the hypotheses of Al Betrugi.[3] But the latter certainly represented a general desire on the part of the Spanish Aristoteleans to overcome the physical difficulties in accepting the Ptolemaic system; thus Averroes says that the astronomy of Ptolemy is merely a convenient means of computing, and that he himself in his youth had hoped to prepare a work on the subject.

Nasir ed-din Al Tūsi

While ineffectual attempts were being made in the far west. to devise a new astronomical theory, the astronomers of the east did not remain blind to the desirability of finding a system, in which the planets were not supposed to move unsupported in space in such a wonderfully complicated manner; and in the thirteenth century we find one of the greatest astronomers, Nasir ed-din Al Tūsi, advocating a system of spheres which he supposed to be more acceptable than excentrics and epicycles.[4] In addition to a review or digest of the *Syntaxis* of Ptolemy he wrote a shorter work entitled *Memorial of Astronomy*, in various

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1. e.g. by Riccioli, *Almag. Nov.* T. I. p. 504, where Kepler's figure of the real motion of Mars in space from 1580 to 1596 (supposing the earth to be at rest) is copied, as if that had anything to do with the "*Spirals*" of Alpetragius.

2. He adds that he was not qualified himself to sit in judgment on the proposed system (*Liber Jesod Olam*, II. 9, p. XI.)

3. Munk, *Melanges* pp. 500 and 521.

4. "*Less spheres celestes selon Nasir-Eddin Al tūsi. Par M. Carra de Vaux.*" Appendix VI. *to Tannery's Recherches sur l'astr. anc.* pp. 337—360. Includes a translation of the chapter in which the new theory is set forth.

passages of which he shows his dissatisfaction with the Ptolemaic system. In the chapter on the Moon (to which we have already alluded) he counts up the various anomalies, among which he mentions the anomaly of illumination, that is, the spots on the Moon, which he believes to be caused by other bodies moving in the lunar epicycle and unequally exposed to the Moon's light. He then says that we should expect in a simple theory to find the centre of the epicycle in equal times describing equal arcs on the deferent, and the diameter of the epicycle joining the pericentre and the apocentre pointing to the centre of the deferent. But neither of these conditions is fulfilled. In the theories of the planets he makes the same objections, which it must be said are very just, since the introduction of the equant was a very unnatural arrangement. But this is nothing to the artificial machinery designed by Ptolemy to account for the motion in latitude of the five planets, especially of Mercury and Venus. Nasir ed-din describes the marvellously complicated movements of the deferents and epicycles of these planets, and remarks that "these motions require the introduction of a system of guiding spheres, about which the ancients have not said anything". He next proceeds in the following chapter to explain a system of his own which allows us to discard these combinations.

First he proves that if there are two circles in one plane, one touching the other internally and of a diameter equal to half that of the other, and if the greater one rotates, and a point moves along the circumference of the smaller one in the opposite direction with twice the velocity and starting from the point of contact, then that point will move along a diameter of the greater circle.[1] These two circles may now be assumed to be the equators of two spheres, and for the point we may substitute a sphere representing the Moon's epicycle (1 in the figure), Nasir ed-din assumes another sphere (2) surrounding the epicycle and destined to keep the diameter from apogee to perigee in its place always coinciding with the diameter of the sphere (4) "let us give it a suitable thickness, but not too great, so as not to take up too much space." He next assumes two more spheres, one (3) which corresponds to the smaller sphere in the distance of the centre of the deferent in the Ptolemaic system from the

1. Compare Copernicus, *De revolutionibus*, III. 4 (Secular ed. 1873, p. 166).

centre of the Earth; and another sphere (4) with a diameter twice as great. Finally (4) is placed in the interior of a carrying sphere (5) concentric with the world and occupying the concavity of the

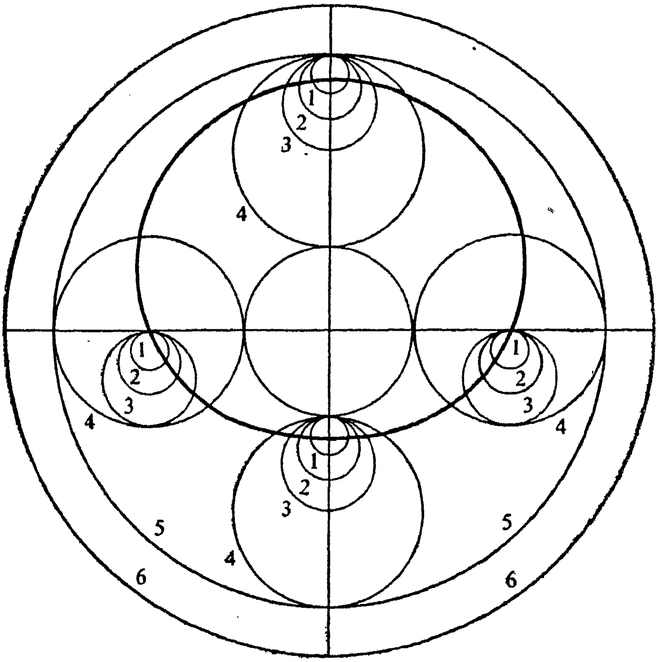


Fig. 3.—Movements of deferents and epicycles of planets.
The thickline is *not* a circle. All others are circles.

sphere (6), the equator of which is in the plane of the lunar orbit. (2) and (4) and (5) revolve in the same period, that in which the centre of the epicycle performs a revolution; (3) revolves in half that time, while (6) revolves in the opposite direction with the same speed as the apogee of the excentric. The figure now shows how the epicycle moves to and fro along the diameter of (4) and during the revolution of the circle (5) describes a closed curve, about which Nasir ed-din justly says that it is somewhat like a circle but is not really one, for which reason it is not a perfect substitute for the eccentric circle of Ptolemy. He estimates the greatest difference between the lunar places given by the two theories as one-sixth of a degree, half-way between syzygy and quadrature. Except for the action of the guiding sphere (2), it would not be the centre of the epicycle but the point of contact of circles (3) and (4), which describes the curve resemblng a circle. The same

method may be adopted for Venus and the three outer planets, and Nasir ed-din promises to explain the new theory of Mercury in an appendix, but this appears to have been lost.

Nasir ed-din also endeavours to improve on the machinery proposed by Ptolemy to illustrate the manner in which the epicycle remains parallel to the plane of the ecliptic. He mentions that the celebrated Ibn al Haitham (afterwards known in the west as Alhazen, author of a well-known book on optics) had written a chapter on this subject, adding to each epicycle two spheres to account for the inclination of the diameter perigee-apogee, and two additional ones for the inferior planets for the diameter at right angles thereto.[1] Nasir ed-din makes use of the same principle which guided him in his demonstration about the motion in longitude, and he shows how in this way we may by means of two spheres make the extremities of the diameter of the epicycle move backwards and forwards along an arc of a sphere.[2] He claims that this arrangement is superior to that of Ptolemy by not introducing any error in longitude,[3] but he acknowledges that he has not been able to get rid of the strong objection to Ptolemy's auxiliary circle, viz. that the irregular motion in longitude with regard to the centre of the deferent necessitates the introduction of a corresponding irregularity in the motion on the auxiliary circle by letting the motion be uniform with regard to an equant. It baffled Nasir ed-din's ingenuity to find an arrangement of spheres which could obviate the necessity of having recourse to this expedient.

All the attempts at rebellion against the Ptolemaic system had thus turned out failures. And they deserved nothing else, since it was impossible to find anything better than what Ptolemy had produced, until it was perceived that where Ptolemy was wrong was not in his mathematical methods, which were perfect, but in the fundamantal idea of the Earth being at rest. The time

1. Ibn al Haitham said that by using discs instead of spheres one might complete the demonstration; but Nasir ed-din objects to the arrangement (about which he gives no details) that a non-spherical system is not in accordance with the principles of astronomy.

2. It is not quite clear whether this plan is his own or is the same as Ibn al Haitham's.

3. Due to disturbance of the position of the diameter from perigee to apogee, from which the anomaly is counted.

was apparently not ripe for a radical change with regard to this idea. Though the doctrine of the Earth's motion does not seem to have been mentioned by Arabian writers, we have evidence that the hypothesis of the daily rotation of the Earth was not unknown among them, a natural consequence of their familiarity with the writers of antiquity. One of Nasir ed-din's fellow-workers at the Meragha observatory, Ali Negm ed-din al Katibi, who died in 1277, wrote a book, the *Hikmat al-ain*, on philosophy, in which he combats this opinion, which he attributes to "some philosphers." "I do not," he says, "advance as an argument against it that, if this were the case, a bird flying in the direction of the motion of the Earth would not be able to keep up with it, because the motion of the Earth would be much faster than that of a bird, inasmuch as it returns to its place in a day and a night. Such an argument is not conclusive, because it may be urged that the atmosphere which is close to the Earth partakes of its motion as the ether partakes of the motion of the heavenly sphere. But I reject this theory, because all terrestrial motions take place in a straight line, and therefore we cannot admit that the Earth should move in a circle."[1]

What reformation of astronomy could be hoped for, as long as this kind of argument could be used ? We cannot see from this remark of Katibi's whether there really were any Arabian philosophers who believed in the rotation of the Earth. It is, however, stated in the *Zohar*, the great Kabbalistic work attributed to Mosheh ben Shemtob of Leon (died 1305), that a certain Rabbi Hamnuna the Elder (otherwise unknown) taught that "the Earth turns like a sphere in a circle and that some people are above and others below."[2] Though this passage as well as others in the Zohar may have been interpolated much later, it would

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1. A. Sprenger, "The Copernican System of Astronomy among the Arabs." *Journ. Asiat. Society of Bengal*, Vol. XXV. (1857), p. 189. Katibi's contemporary, Abu 'l Faraj (II. p. 10) deems it necessary to prove that the Earth cannot be in motion, neither rectilinear nor circular, but his arguments (about birds and stones flung upwards) seem merely taken from Ptolemy, lib, 1. cap. 6, Kazwini (*Kosmographie*, p. 296) says that among the ancients there were some adherents of Pythagoras who maintained that the Earth continually moves round in a circle ; but whether these adherents were Greeks or Arabians cannot be seen from the context.
2. *Sohar*, Amsterdam, 1718, T. III. f. 10a ; Gunther, *Studien Z. Gesch, d. math, Geogr.*, p. 113.

after all not be very surprising if some learned Jews had been influenced by the opinion of Herakleides, since it is an established fact that the doctrines of the Kabbalists were intimately connected with the later Greek philosophy. But any how nothing came of this isolated case, and the daily rotation of the heavens continued to be universally accepted as a self-evident fact.

Arabian astronomers and Ptolemaic system—

Arabian astronomers who really wished to follow in detail the celestial motion were therefore obliged to adopt the Ptolemaic system altogether. New planetary tables had long been found to be a necessity, and this important work was at last undertaken by King Alfonso X. of Castille and several Jewish and Christian astronomers working under him at Toledo, who prepared the celebrated Alfonsine Tables, Apparently the King must have had his doubts about the physical truth of the system, judging from his well-known saying that if God had consulted him when creating the world, he would have given Him good advice. The tables were prepared under the direction of the Jew Ishak ben Said, called Hasan, and a physician, Jehuda ben Mose Cohen, and were finished in 1252, the year in which Alfonso ascended the throne of Castille. They continued in great repute for three hundred years as the best planetary tables; they were first printed in 1483, but had been spread all over Europe long before that time in numerous MS copies, many of which are still in existence, Twenty-six codices are counted up in the *Libros del Saber de Astronomia del Rey D. Alfonso X.de Castella,* Madrid, 1863–67 (5 vols. fol.). This compilation, a series of chapters on spherical and theoretical astronomy followed by tables, must have been made up from several codices, as there are numerous repetitions even of very elementary matters. In the third volume the theories of the planets are dealt with, but one looks in vain for any improvement on Ptolemy; on the contrary, the low state of astronomy in the Middle Ages is nowhere better illustrated. In general the elements of the orbits are these of Ptolemy, though sometimes only approximations are given, while different values are given in different chapters, though Ptolemy places the centre of the deferent midway between the centre of the equant and the Earth, the *Libros del Saber* places the centre of the equant (*cerco del alaux.*[1]) midway between the Earth and the centre of the deferent

1. *al* is the Arbic article, *aux* (apside) is a corruption of the Arabic *Oudj* (Abu 'l Faraj, II. p. 25). The equant is called the *cerco del Y guador.*

(*cerco del levador*[1]), as in Ptolemy's theory of Mercury, which the authors would seem to have extended to the planets, omitting the motion of the centre of the deferent on a small circle; this, they have, however, correctly given in the case of Mercury.[2] There is a very curious figure[3] of the deferent of Mercury in the form of an ellipse (the axes being as 6 to 5 nearly), with what looks like the Sun in the centre. This curve has been constructed from a number of small circular arcs,[4] and it is obviously nothing but the curve described by the centre of the epicycle of Mercury in Ptolemy's theory. For according to the latter the centre of the deferent describes a small circle with radius=$\frac{1}{21}$ of that of the deferent, in direction from east to west, in the same time which the centre of the epicycle takes to pass round the circumference of the deferent from west to east. This makes the centre of the epicycle describe a closed curve resembling an ellipse, the axes of which are in the ratio 11: 10, almost exactly the same as in the Spanish diagram, and there is therefore in the latter no anticipation whatever of Kepler's great discovery, since in the case of the inferior planets it is the epicycle which is the real orbit.[5] The small sun-like object in the centre of the ellipse represents the centre of Ptolemy's small circle, and it has either been inserted in the manuscript centuries after the essay had been written, or, more likely, it has been caused by a small blot on the place in the parchment where the stationary leg of the draughtsman's compasses had made a small hole. An oval deferent of Mercury occurs in several books published in the sixteenth and seventeenth centuries.[6]

1. Vol. III. pp. 246—253.
2. Vol. III, pp. 253 and 278. In the the latter place the radius of the small circle is $\frac{1}{21}$, as in the "*Hypotheses*" of Ptolemy.
3. Vol. III. p. 282.
4. See the lengthy description on pp, 278—280.
5. The editor, Don Manuel Rice y Sinobas, on p. xxxiii, of his preface, even goes so far as to suggest that Kepler may have known of this great discovery of Alfonso's or rather of Arzachel's, as the text attributes the construction to him. This and other similar diagrams were intended to be used instead of planetary tables in the manner afterwards adopted by Apianus.
6. First (about 1460) in Purbach's *Theoricae novae Planetarum* (ed. of Basle, 1573, p. 82): "Ex dictis apparet manifeste, centrum epicycle Mercurij,

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Though the somewhat confused collection of essays entitled the *Libros del Saber* would not, if published in the thirteenth century, have advanced astronomical science, it cannot be denied that the Alfonsine Tables were very useful in their day. The actual elements are not given, nor is any thing said about any observations by which somewhat more correct values of the mean motions must have been found.[1]

Arabs on motions of fixed stars.

Thus we finish our review of the planetary theories of the Arabs. Now we shall say a few words about their ideas as to the nature and motion of the fixed stars. The exaggerated notion which prevailed before the invention of the telescope with regard to the apparent angular diameters of the stars naturally, led to erroneous estimates of their actual size, founded on the assumption that the sphere of the fixed stars (the eighth sphere) was immediately outside that of Saturn.[2] The stars of the first magnitude were supposed to have an apparent diameter equal to $\frac{1}{20}$ of that of the Sun, from which it followed that their actual diameters were about $4\frac{3}{4}$ times that of the Earth, or about

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propter motus supradictos non (ut in alijs planetis fit) circumferentiam deferentis circularem, sed potius figuræ, habentis similitudinem cumplana ovali peripheriam describere." Next by Albert of Brudzew in 1482 in his *Commentariolum super theoricas novas*, printed at Milan in 1495 (ed. Cracow, 1900, p. 124), where it is remarked that the centre of the lunar epicycle describes a similar figure. This is also stated by E. Reinhold in his commentary to *Purbach*, 1542, fol. p. 7 verso (ed. of Paris, 1558, fol. 78.) by Vurstisius in his *Questiones novae in theoricas*, & c., Basle, 1573, p. 233 ; and in Riccioli's *Almagestum novum* T. I. p. 564. The last three writers (who give a figure) also take the equable angular motion round the centre of the equant into account, which centre lies on the point of the circumference of the small circle nearest the Earth. The curve described by the centre of the epicycle thus becomes egg-shaped, and not like an ellipse.

1. The tables in vol. v. of the *Libros del Saber* are quite different from the Alfonsine Tables, and are apparently only intended for astrological purposes.
2. Al Battani (cap. 50) gives the greatest distance of Saturn=18,094. and the distance of the fixed stars=19,000 semidiameters of the Earth. Al Fargani (p. 82) puts them exactly equal. Al Kusgi gives the diameters in parasangs, of the concavity of the stellar sphere=33,509,180 of the ninth sphere 33,524,309, of its convexity "no one but God knows" (Shah Cholgi, p. 97).

twice that of Mars.[1] As to the nature of the stars, they seem generally to have been assumed self-luminous, being condensed parts of the sphere, though Abraham ben Chija says that the eighth sphere does not shine with a uniform light, but has denser spots, which are illuminated by the Sun and appear to us as the fixed stars.[2]

To account for the apparent slow motion of the stars paralleled to the ecliptic, from west to east, whereby their longitudes increase while their latitudes remain unaltered, it became necessary to inroduce a ninth sphere (*primum mobile*), turning in twenty-four hours and communicating this motion to the eighth sphere, while the latter moved extremely slowly round its own axis forming an angle of 23° 35′ with that of the ninth.[3] But the simple phenomenon of precession was by many Arabian astronomers complicated by being assumed variable. It may be mentioned that according to Theon and Proklus it had been assumed by some astronomers apparently before the time of Ptolemy, that the precessional motion of the stars was not progressive, but was confined to an oscillation along an arc of 8°, along which the equinoctial points moved backwards and forwards on the ecliptic, always at the same rate of 1° in 80 years. The absurdity of the sudden change of direction must have become obvious as soon as astronomy began to be cultivated among the Arabs, for we find that one of the earliest astronomers, Tābit ben Korra, substituted a physically less objectionable theory.[4]

1. Al Fargani (p. 85, Golius) gives the cubic contents of the six spheres as 107, 90, 72, 54, 36, 18 times that of the Earth. Abu 'l Faraj, p. 199, gives a similar series from 93 to 15¼ for the average star of each class. Shems ed-din of Damascus in his *Cosmography* (p. 3) merely says that the smallest fixed star is much larger than the Earth.

2. According to Suter, p. 77. a writer called Ibn Zura wrote a treatise "On the cause of the light of the stars, though they and the spheres consist of one single substance."

3. The outermost sphere is by the philosopher Ibn Sina (Avicenna) defined as a spherical, single (not composite) body, emanating directly from God and subject to dissolution, endowed innately with circular motion as an expression of its praise of the Creator (Mehren in *Oversigt, K. Danske Vid, Selskab*, 1883, p. 70).

4. The treatise "*On the motion of the 8th sphere*" has never been printed; an abstract is given in Delambre's *Hist. de l'astr. du Moyen Age*. p. 73. Compare a quotation by Ibn Junis, Caussin, *Notices et Extraits*. VII. p. 116.

He imagines a fixed ecliptic (in the ninth sphere) which intersects the equator in two points (the mean equinoxes) under an angle of 23° 33′ 30″, and a movable ecliptic (in the eighth sphere), attached at two diametrically opposite points to two small circles, the centres of which are in the mean equinoxes and the radii of which are=4° 18′ 43″. The movable tropical points of Cancer and Capricorn never leave the fixed ecliptic, but move to and fro to the extent of 8° 37′ 26″, while two points on the movable ecliptic 90° from the tropical points move on the circumferences of the small circles, so that the movable ecliptic rises and falls on the fixed one, while the points of intersection of the equator and the movable ecliptic advance and recede to the extent of 10° 45′ either way, This is a motoin of the eighth sphere, common to all stars, and the Sun will, therefore, sometimes reach its greatest declination in Cancer, sometimes in Gemini. Tabit does not say that the obliquity of the ecliptic is variable, and perhaps it did not occur to him that this would be a necessary consequence of his theory; he only notices the change in direction and amount of the motion of the equinoxes, which, he says, has increased since the days of Ptolemy, when it was only 1° in 100 years, while later observers have found 1° in 66 years. The erroneous value given by Ptolemy was, therefore, mainly responsible for the continuance of the imaginary theory. It is to be observed that Tabit expresses himself with a certain reservation, and seems to think that further observations are necessary to decide if the theory is true or not. His younger and greater contemporary Al Battani was even more cautious, for though he repeats the account of the trepidation given by Theon (which he says that Ptolemy *manifeste in suo libro declarat*[1]) he does not make use of it, but simply adopts 1° in 66 years (or 54″.5 a year), which he finds by a comparison between his own observations and some made by Menelaus. In rejecting the erroneous value of Ptolemy, which Al Fargani alone had accepted,[2] Al Battani was followed by Ibn Jūnis, who came still nearer to the truth by adopting 1° in 70 years or 51″.2 a year, and who does not allude to trepidation. It is greatly to the credit of several other Arabian writers that they were not led astray by this imaginary phe-

1. Cap. 52, (205). Plato's translation gives the period as 84 years, but Nallino's ed. has 80 (p. 127).

2. c. 13, p. 49.

3. Schjellerup, *Descr. des etoiles fixes*, p. 43,

nomenon; among them are Al Sūfi, the author of the only uranometry of the Middle Ages[3], who followed Al Battani, also Abu 'l Faraj and Jagmini,[1] while Nasir ed-din mentions it but seems to doubt its reality.[2] By others it was willingly accepted, for instance by Al Zarkali, who made the period of oscillation of 10° either way equal to 2000 Muhammedan years (or 1940 Gregorian years, i.e. 1° in 97 years or 37″ a year). The motion is in a circle of 10° radius; at the Hijra the movable equinox was it 40′ in increasing precession, and in A. D. 1080 at 7° 25′.[3]. The diminution of the inclination of the ecliptic, which the astronomers of Al Mamun had found=23° 33′, no doubt lent countenance to the idea of trepidation, and the next step in the development of this curious theory was the combination of progressive and oscillatory motion. Al Betrugi, who gives a sort of history of the theory, beginning with a mythical H mes, makes out that Theon (or Taun Alexandrinus as he calls him) combined the motion of 1° in 100 years with the oscillation[3]. A century later this was actually done, and the theory received its last development by King Alfonso or his astronomers, who[4] perceived that the equinoxes had receded much further than Tabit's theory allowed. The equioxes were now supposed to pass right round the heavens in 49,000 years (annual motion=26″.45), while the period of the inequality of trepidation was 7000 years, so that in a sort of Great Jubilee year everything was again as it had been in the beginning.[5] The progressive motion belongs to

1. Abu 'l Faraj, p. 12, simply says that the motion is 1° in 100 years according to Ptolemy, or 1° in 66 years according to others. But on p. 18 he says that if the ancient Chaldeans gave the tropical points a motion backwards and and forwards, and if ancient astrologers adopted this, then the motion of the fixed stars must have been unknown to them. Jagmini (p. 229) says that most people adopt 1° in 66 solar years.
2. *Spheres celestes*, p. 347.
3. Sedillot, *Memoire sur les instr. astr. des Arabes*, pp. 31, 32. Abraham ben Chija (p. 196 of Munster's *Sphaera mundi*. Basle, 1546) gives the period as 1600 years without quoting any authority. He adds that the ancient Indians, Egyptians, Chaldeans, Greeks, and Latins first proposed the theory—Ptolemy neither approved nor disapproved of it, but Al Battani confuted it.
4. Alpetragius, f. 12a. He says that Al Zarkali did the same.
5. A later writer, Augustinus Ricius, *De motu octave sphaere*, Paris, 1521, who traces the theory back to Hermes, 1985 years before Ptolemy (!) credits

(Continued on next page)

the ninth sphere; the annual precession varies between 26″.45± 28″.96, or from + 55″.41 to −2″.51.[1] It was now necessary to assume the existence of a tenth sphere, which as primum mobile communicated the daily rotation to all the others, while the ninth produced the progressive and the eighth periodical motion on the small circles, which are situated "in the concavity of the ninth sphere." This was a nice and comfortable theory on account of the long periods involved and the slow changes it produced in the amount of annual precession; and oblivious of the fact that the theory had no foundation except the circumstance that the obiquity of the ecliptic was now about 20′ less than it had been stated to be by Ptolemy, and that he had given the amount of precession as 36″ a year instead of about 50″, and often shutting their eyes to several of the necessary consequences of it, such as the changes in the latitudes of stars which it ought to produce[2], astronomers continued to accept the theory until at last a real observer of the stars arose and wiped it out by showing that the obliquity of the ecliptic had steadily diminished, and that the amount of annual precession had never varied. We have in this place only alluded to it because it involved some rearrangement of the spheres and because it is eminently characteristic of the period during which no persistent observations were taken, and hardly an attempt was made to improve the theories of Ptolemy. The theory of *trepidatio* or *titubatio*, as it was sometimes called, was one attempt and it would have been better left alone. But it forms a not uninteresting chapter in the history of astronomy.

(Continued from previous page)

this development to a Jew of Toledo, Isaac Hassan (see above. p. 38), adding that Alfonso four years after the completion of the tables became convinced of the futility of the theory by reading the book on the fixed stars by Al Sufi. Riccioli, *Almag. novum*, I. p. 166.

1. In the Alfonsine Tables the maximum took place at the birth of Christ. In Essler's *Speculum astrologicum*, p. 224 (appended to Purbach's *Theoricae novae*, Basle, 1573) the epoch is A.D. 15, diebus 137 completis. Reinhold in his commentary to Purbach (Paris, 1558, f. 163b) explains that 26″.45 is the space passed over by the Sun in 10 mins. 44 secs., by which amount the Alfonsine Tables made the tropical year smaller than 365¼ days.
2. Abraham ben Chija (p. 103, *Schrackenfuchs*) says that trepidation does not change the latitudes. Perhaps he refers to the earliest form of the notion, that described by Theon of Alexandria.

Here we finish our review of ancient astronomy. We have omitted as not coming within our province several valuable contributions to science which did not deal with cosmology or planetary theory. But even with this limitation enough has been said to show that when Europeans again began to occupy themselves with science they found astronomy practically in the same state in which Ptolemy had left it in the second century. But the Arabs had put a powerful tool into their hands by altering the calculus of chords of Ptolemy into the calculus of sines or trigonometry, and hereby they influenced the advancement of astronomy in a most important manner.

References

1. Peter Doig : *A Concise History of Astronomy* London 1950.

1. J.L.E. Dreyer : *A History of Astronomy from Thales to Kepler Dover publications*, 1953 (chapter XI reproduced).

3. Satya Prakash : *Founders of Sciences in Ancient India*, Delhi, 1965.

CHAPTER II

Personal References of Brahmagupta

Sudhākara Dvivedī in his *Gaṇaka Taraṅgiṇī*, a small book on biographical skethes of astronomers and astrologers of this country gives a brief account of Brahmagupta thus :

Brahmagupta was born in 520 Śaka (655 Vikramī or 589 A.D.) in the reign of King Vyāghramukha, belonging to the *Cāpa* family ; his father was Jiṣṇugupta ; and at the age of 30, he wrote in 550 Śaka (628 A. D.) his well known treatise on Astronomy known as the *Brāhmasphuṭasiddhānta*, which is corroborated by the statement in the *Viṣṇudharmottara Purāṇa*, (Chapter on the *Brahma-siddhānta*), His other treatise, entitled the *Khaṇḍa-Khādyaka*, which is a *karaṇa* book, was completed in 587 Śaka (665 A. D.). According to some authorities, Brahmagupta was the grandson of Viṣṇugupta, and the family suffix (*Gupta*) indicated that he belonged to the Vaiśya family, and he was in the service of the King of Rewah, known as Vyāghrabhaṭa.

Brahmagupta was a great critic ; he did not spare any of his predecessors like Āryabhata, Varāhamihira, Śrīṣeṇa, Viṣṇucandra and others. Later on, his influence on the writing of the succeeding generations has been immense. Bhāskarācārya II in his *Bījagaṇita* has acknowledged him as a great authority on algebra and has given him as the first place amongst the galaxy consisting of Brahmagupta, Śrīdhara, Padmanābha etc. The Eighteenth Chapter of the *Brāhmasphuṭasiddhānta*, known as Kuṭṭaka Chapter (on Pulveriser) has been translated by H. T. Colebrooke in English in 1817. The English translation of the Twelfth Chapter on Gaṇita or Calculations from the *Brāhmasphuṭasiddhānta* is also available in English. (See Colebrook's *Algebra with Arithmetic and Mensuration from the Sanskrit of Brahmagupta and Bhāskara*, London, 1817).

The *Vāsanā Commentary* on the Brāhmasphuṭasiddhānta by Pṛthūdakasvāmī (860 A. D.) is also available though with difficulty (as indicated by Sudhākara Dvivedi) ; its incorrect manus-

cript is available in the Library of the King of Banaras (Kāśirāja) which has the colophony at the end as :

> श्री चापवंशतिलके श्री व्याघ्रमुखे नृपे शकनृपालात् ,
> पञ्चाशत्संयुक्तैर्वर्षशतैः पञ्चभिरतीतैः ।
> ब्राह्मस्फुटसिद्धान्तः सज्जनगणितज्ञगोलवित्प्रीत्यै,
> त्रिंशद्वर्षेण कृतो जिष्णुसुतब्रह्मगुप्तेन ॥

Bhāskara II has written the famous treatise *Siddhāntaśiromaṇi* (1150), which is almost based on the *Brāhmasphuṭasiddhānta.* It has been edited by the author's own gloss (*Vāsanābhāṣya*) by Bāpu Deva Śāstrī (Vārāṇasī); by Murlīdhar Jha with the commentaries, *Vāsanāvārttika* of Nṛsiṁha (1621) and Marīci of Munīśvara (1635), vol. I (containing chapter 1 of the *Gaṇitādhyāya*) (Vārāṇasī, 1917); by Girija Prasad Dvivedi with original commentaries in Sanskrit and Hindi, vols. I and II (Lucknow, 1911, 1926); English translation of the text only by Bāpu Deva Śāstrī and Wilkinson (Calcutta, 1861).

In the very first Chapter (verse 2), Brahmagupta writes: The old calculations dealing with planets (i.e. the old astronomy), based on the system of Brahmā have become erroneous in course of past ages and therefore, I, the son of Jiṣṇugupta would like to clarify them.

Brahmagupta was not a mere theorist, he based his calculations on direct observations with the help of instruments or devices (*nālikādi yantra*); he was in favour of making corrections on the basis of these observations. He was himself an expert *observer*. In his *Khaṇḍakhādyaka* also he has emphasised the need of direct observation.

At many places, Brahmagupta has severely criticised the Romaka and Pauliśa systems of astronomy which were introduced in this country by Lāṭadeva and Śrīṣeṇa, There are many passages where this criticism would be available with vehemance.

Brhamagupta was opposed to the system of Āryabhaṭa I. He never spares the school of Āryabhaṭa which was regarded as the most authoritative then. Sudhākara Dvivedi says that as Brahmagupta was opposed to the system of Āryabhaṭa, so the Vaṭeśvara Siddhānta was opposed to that of Brahmagupta. The Institute has already published the *Vaṭeśvara Siddhānta* and now it has the privilege of publishing the *Brāhmasphuṭasiddhānta.*

A Note on Bhillamāla

It is said that Brahmagupta completed his *Brāhmasphuṭa-siddhānta* in Śaka 550, and he has come to be known as Bhillamālakācārya or a teacher residing in "Bhillamālaka." In this connection, therefore, it would be interesting to reproduce a note on *Bhillamāla* from G. Bhūler's article on *Gurjara Inscriptions*, No. III, published in the *Indian Antiquary*, July 1888, vol. 17, p. 192 :

With a single exception all the complete inscriptions call the princes enumerated above, scions of the Gurjara race; and *Khe* I. and II. highly extol the greatness and wide extent of this family. *Na.* alone names the Mahārāja Karṇa as their ancestor. With respect to this personage it is for the present impossible to say whether the famous hero of the *Mahābhārata* may be meant, or some real historical king. But the name *Gurjara* makes it evident that this dynasty belonged to the great tribe which is still found in Northern and Western India and after which two provinces, one in the Bombay Presidency and one in the Pañjāba, have been named. The Gurjaras or *Gūjars* are at present pretty numerous in the western Himālaya, in the Pañjāba and in Eastern Rājpūtānā. In Kachh and Gujarāt their number is much smaller. It would, therefore, seem that they came into Western India from the north. Their immigration must have taken place in early times, about the beginning of our era or shortly afterwards. In Western India they founded, besides the kingdom of Broach, another larger state which lay some hundred miles further north. Hiuen Tsiang mentions in his travels[1] the kingdom of *Kiu-che-lo* and its capital *Pi-lo-mi-lo.* It has been long known that the former word corresponds to Gurjara.

But the name of the town has been incorrectly connected by the French scholars with Bālmer in the Jēsalmīr territory, and this identification has been accepted in Mr. Beal's new translation of *Siyuki.* As I have stated already formerly[2] following Colonel. J. Watson, *Pilomilo* corresponds exactly to Bhillamāla

1. Beal, *Siyuki,* Vol. II, p. 269f. Hiuen Tsiang assigns to the northern Gurjara State an extent about double of that given for the kingdom of Broach.

9. *Ante.* Vol. VI. P. 63.

one of the old names of the modern Bhīnmāl or Śrīmāl[1] in southern Mārvāḍ close to the northern frontier of Gujarāt. Another work, which was composed a few years before Hiuen Tsiang's visit to Gujarāt, contains likewise a notice of this northern kingdom of the Gurjaras. The astronomer, Brahmagupta, who completed his *Siddhānta* in Śaka-Samvat 550 or 628 A.D. calls himself Bhillamālakakācārya[2], "the teacher residing in Bhillamālaka and is called so by his commentator Pṛthūdakasvāmin. He further states that he wrote under king Vyāghramukha who was 'an ornament of the Cāpa race.' This family, whose name recurs in the Haḍḍāla grant of Dharaṇivarāha[3] prince of Vadhvān, thus seems to have been the reigning house of Bhillamāla. It is most probably identical with the Cāuḍās, Cāvóṭakas[4] or Chāpótkaṭas, who from 756 to 941 A.D. held Aṇhilvāḍ and still possess various small districts in northern Gujarāt. The Gurjara kingdom of Broach was without a doubt an offshoot of the larger State in the north, and it may be that its rulers, too, belonged to the Cāpa family.

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1. Bhillamāla means etymologically 'the field of the Bhil' and Śrīmāla 'the field of Sri'. The latter name must also be ancient, as the Śrīmāli Brāhmaṇ as are called after it. The Jainas narrate various, of course incredible, legends, which explain how Śrimāla came to be called Bhillamāla. Merutuṅga says that king Bhoja invented the latter name, because the people of Śrimāla let the poet Māgha die of starvation. According to another authority, the town had a different name in each Yuga. It is in India very common for ancient towns to have two or even more names. Thus Kanauj was called, Kānyakubja, Gādhipura, and Mahodaya.

2. See Professor A. Weber. *Die Sanskrit und Prakrit Handschriften der Berliner Bibliothek* Vol. II. pp. 297-298. In the first passage the MSS. offers incorrectly Bhilamācārya; in the second which occurs in the commentary on the Khaṇḍakhādyaka, we have Bhillamālavakācārya, a slightly corrupt reading. This latter varia lectio occurs also in other MSS., see Weber, *Indische Streifen*. Vol. III, p. 90, and has given rise to erroneous suppositions regarding Brahmagupta's home, The Gujarāti Joshis still preserve the tradition that Brahmagupta was a native of Bhinmāla.

3. Ante, Vol. XII. p. 190ff. The remark which I have made there that the Cāpas are not named elsewhere, of course requires correction.

4. The form Cāvoṭaka, which occurs in Dr. Bhagavanlal's grant of the Gujarāt Cālukya king Pulakeśin of Samvat 490, is the immediate predecessor of the word Cāuḍā. Its Sanskrit original is certainly not cāpotkaṭa which probably has been coined in comparatively speaking modern times, in order to explain the difficult Prakrit word, just as the bards of Rajputana have invented Rāṣṭrauḍha as etymon for Rāthoḍ.

Brahmagupta's own References

In the Twenty-fourth Chapter (*Sañjñādhyāya*), of the *Brāhmasphuṭasiddhānta*, Brahmagupta has made a reference to his own biography : In the reign of Vyāghramukha belonging to the family of Cāpa, in the year 550 Śaka the treatise *Brāhmasphuṭasiddhānta* was composed for the benefit of benevolent astronomers by Brahmagupta, son of Jiṣṇugupta at the age of 30. (*BrSpSi.* XXIV. 7. 8)

Then again he says : The *Brāhmasphuṭasiddhānta* has been written by Brahmagupta, son of Jiṣṇu, in 1008 verses of Āryāchanda. (ibid 10)

In the beginning of this Sañjñādhyāya, he refers to the differences in fundamental notions created by the various existing systems of astronomy as the *Sūrya-siddhānta, Puliśa-siddhānta. Romaka-siddhānta, Vasiṣṭha-siddhānta* and other *Yavana-siddhāntas,* which have caused anomalies in the calculations of eclipses. He also refers to the anomalies due to the calculations based on midnight day-reckoning and sunrise day-reckoning.

From the point of view of own references, the following would be of interest:

Brahmagupta, son of Jiṣṇugupta (Jiṣṇusuta-Brahmagupta) :
BrSpSi. I. 2; XVI. 35. 37; XXIV. 8. 10; XXV. 73.

It is strange that in the *Khaṇḍakhāḍyaka*, Brahmagupta has not given his name nor his father's name anywhere. At least the reading of the *Khaṇḍakhāḍyaka* as given by Pṛthūdakasvāmī does not contain this name. In the edition of Bhaṭṭotpala, there are three more chapters in the *Khaṇḍakhādyaka* (Chapters IX, X and XI). In the Chapter XI (known as *Pātādhikāra*), we have 21 verses and in the last 21st verse we find the name of Brahmagupta,[1] son of Jiṣṇu mentioned :

> Those who are eager to have the knowledge of the motion of stars and planets, for them and for the benefit of disciples in this field, Brahmagupta son of Jiṣṇu has composed this *Khaṇḍakhādyaka.*

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1. खण्डखाद्यकमिदं तृप्त्यर्थं ग्रहगतिजुधार्त्तानाम् ।
शिष्याणां हितार्थं प्रोक्तं जिष्णुसुतब्रह्मगुप्तेन ॥ —*KK. XI. 21*

Reference to Āryabhaṭa

We have said that it appears that Brahmagupta was a bitter opponent of Āryabhaṭa in his younger days (628 A. D.), but later on (in 665 A. D.), he climbed down to describe and teach one of the Āryabhaṭa's system of astronomy. Āryabhaṭa was universally revered. and it was difficult for Brahmagupta to have ignored him and thus he has to refer to this great authority some times to oppose some of his views and some times to expound his views. The following are the pasages in the *Brāhmasphuṭasiddhanta*, where the author has referred to the name of Āryabhaṭa. There are many other passages where the name "Āryabhaṭa" does not occur but where Brahmagupta indirectly means to quote the views of this great master.

BrSpSi. I. 9. 12. 28. 32. 60. 61 ; II. 33. 46; V. 21.25; VI. 13; IX.10; XI. 4. 9. 10. 12. 25. 29. 33. 41. 42. 43. 44, 46, 47. 49, 62; XIII, 27; XIV. 45; XVI. 37. 46; XXI. 39.

The largest references are in Chapter XI, where Brahmagupta has made an attempt to show the discrepancies of the Āryabhatiaya system of reckoning astronomical observations and constants.

In the *Khaṇḍakhādyaka* also there is a reference to the name of Āryabhaṭa but on very few occasions. In Chapter I, we have this reference at three places-

> Having made obeisance to God Mahādeva, who is the great cause of this world's rise (i.e. creation), existence and destruction, I shall declare the *Khaṇḍakhādyaka* (i.e. a short treatise on astronomy. which is as pleasant as food prepared with sugarcandy),which will yield the same results as the great astronomical treatise of Āryabhaṭa. As in most cases calculation by the great work of Āryabhata, for (the knowlege of time and longitude of planets etc. at) marriage, nativity and the like, is impracticable for common use every day, this smaller treatise is made so as to yield the same results as that.[1]

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1. प्रणिपत्य महादेवं जगदुत्पत्तिस्थितिप्रलयहेतुम् ।
वक्ष्यामि खण्डखाद्यकमाचार्य्यार्य्यभट तुल्यफलम् ॥
प्रायेणार्य्यभटेन व्यवहारः प्रतिदिनं यतोऽशक्यः ।
उद्वाहजातकादिषु तत्समफललघुतरोक्तिरतः ॥ —*KK. I*, 1-2

These two verses show that Brahmagupta was not hostile to Āryabhaṭa when he wrote this *Khaṇḍakhādyaka* ; he merely intends presenting the subject matter on simple lines and furnishing the results obtained by Āryabhaṭa in a simpler way.

In the following verse of the same chapter, he refers to Āryabhaṭa's midnight day-reckoning system :

> The mean Saturn diminished by 3 seconds, the Śighrocca of Mercury diminished by 22 seconds, the mean Mars increased by 2 seconds and the mean Jupiter increased by 4 seconds are equal to the respective mean planets of Āryabhaṭa's "midnight-system".[1]

In the Appendix of the *Khaṇḍakhādyaka* known as *Khaṇḍakhādyakottara*, we again find a few verses where the name of Āryabhaṭa occurs; Three of these verses have been reproduced from the *Brāhmasphuṭasiddhānta (BrSpSi* I. 62, 63; II.47) :

> Āryabhaṭa made the apogee of the Moon as moving more quickly and the node as moving more slowly than their actual motions ; if his constants give correct results in relation to the end of *tithis* [i. e. conjunction etc.] or eclipses, they must be considered as accidental as are the letters cut into wood by weevils. (*KK*. IX.1; *BrSpSi*. I. 62)
>
> On seeing me, who possess the most accurate knowledge of mean motions, men who have learnt from the works of Śrīṣeṇa, Viṣṇucandra and Āryabhaṭa, cannot face me in any meeting just like deer on seeing a lion (*KK*. IX. 2; *BrSpSi*. I. 63)
>
> As the apparent planets beginning with Mars as derived from the works of Śriṣeṇa, Āryabhaṭa and Viṣṇucandra, are far deviated from their true places, the works of these authors are therefore not valued among the learned.[2] (*KK*. IX. 3; *BrSpSi*. II. 47)

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1. तिसृभिः शनिर्ज्ञशीघ्रं द्वाविंशत्या कुजोऽधिको द्वाभ्याम् ।
चतसृभिरधिको जीवोऽर्द्ध रात्रिकार्य्यभटमध्यसमाः ॥ — *KK.I.7*

2. अकृतार्य्यभटः शीघ्रगमिन्दूच्चं पातमल्पगं स्वगतेः ।
तिथ्यन्त ग्रहणानां घुणाक्षरं तस्य संवादः ॥१॥
मध्यगतिज्ञं वीक्ष्य श्रीषेणार्य्यभट विष्णुचन्द्रज्ञाः ।
सदसि न भवन्त्यभिमुखाः सिंहं दृष्ट्वा यथा हरिणाः ॥२॥
दूरभ्रष्टाः स्पष्टाः श्रीषेणार्य्यभटविष्णुचन्द्रेषु ।
यस्मात् कुजादयस्ते विदुषां नैवादरस्तस्मात् ॥३॥ — *KK. IX. 1-3*

In the Appendix of the *Khaṇḍakhādyaka*, there is another verse which also speaks in the same strain against Āryabhaṭa (this verse does not occur in the *Brāhmasphuṭasiddhānta*) :

> As the process of finding the apparent places of planets as given by Āryabhaṭa does not make them agree with observation, I shall, therefore, speak of this process. Of the Sun the apogee is at two signs and seventeen degrees (*KK*. IX. 4)[1]

Brahmagupta opposed to Śrīṣeṇa—Viṣṇucandra, Lāṭa, Vijayanandī and others

Brahmagupta was a great critic; he did not spare Āryabhaṭa, and along with him he was vehemently opposed to the doctrine of Śrīṣeṇa, Viṣṇucandra, Lāṭadeva, Vijayanandī and Pradyumna also. He was opposed to the *Romaka* and *Pauliśa Siddhāntas*, which were the systems of foreign astronomy, derived from Greece, Babylonia and other centres of learning. He did his best to resist the foreign influences on astronomy.

The following are the verses in the *Brāhmasphuṭasiddhānta*, where Brahmagupta expressed his note of discord against the systems or notions of Āryabhaṭa, Śrīṣeṇa and Viṣṇucandra :

BrSpSi. I.60; II 46, 47; X 13, 62; XI.31, 46, 47, 48-50, 55, XVI. 36, 46; XXI.39; XXII. 2.

In two of the verses, he refers to Lāṭasiṃha :

BrSpSi. XI. 46, 48.

In the following verse, he refers to Aṅkaciti, Vijayanandī, Pradyumna and others: *BrSpSi*.XI. 58.

In the *Khaṇḍakhādyaka* we do not find the names of these adversaries of Brahmagupta ; we, however, have a reference of Śrīṣeṇa, Āryabhaṭa and Viṣṇucandra in the verses already quoted, occurring in the Appendix of the *Khaṇḍakhādyaka* (*Khaṇḍakhādyakottara*), Chapter IX. 2 and 3. As we have said before, these verses of the Appendix have been reproduced from the *Brāhmasphuṭasiddhānta*. (I.62 and II.47).

Reference to Romaka and Pauliśa systems

Brahmagupta speaks of his system as if expounded by Brahmā himself for the first time, later on deteriorated, and then revived by Brahmagupta himself. The very second verse of the *Brāhma-*

1. न स्फुटमार्यभटोक्तं स्पष्टीकरणं यततस्ततो वक्ष्ये ।
भानुमतो मन्दोच्चं राशिद्वयमंशकाश्च सप्तदश ॥ —*KK. IX. 4.*

sphuṭasiddhānta (I. 2) substantiates this view :

The science of astronomy (or the calculations of heavenly bodies) in course of long duration became ineffective or erroneous; this was revived by Brahmagupta, son of Jiṣṇu.[1] (*BrSpSi.* I.2).

The system of astronomy which goes by the name Brahma (*Brahmasiddhānta*) has been handed down to us in three forms : (i) one is as treated by the *Śākalya Saṃhitā*, (ii) one as described in prose in the *Viṣṇudharmottara Purāṇa*, and (iii) the one described by Varāhamihira in the *Pañcasiddhāntikā*, which recognises the *yuga* of the duration of five years. Which of these three was accepted by Brahmagupta is not clear. But from the measures of the number of revolutions performed by a planet in a given period (*graha-bhagaṇa*) etc., it is clear that Brahmagupta acknowledges the system as propounded in the *Viṣṇudharmottara Purāṇa*. In his chapter "*Tantra-parīkṣādhyāya* or *Dūṣaṇādhyāya*, he contradicts the notions of the *Vedāṅga Jyotiṣa* which accepts the *yuga* of five years.

We may further emphasize the fact that Brahmagupta has not clearly detailed out the errors to which the Brahma-siddhānta succombed in course of time, and how these errors were eradicated by him. During the days of Brahmagupta, Romaka and Pauliśa systems were getting currency in this country. Reference to these two are found in the *Brāhmasphuṭasiddhānta* at several places as follows :

ROMAK : I.13; XI.50; XXIV.3
PAULIŚA : XIV.45; XXIV.3

In fact, *BrSpSi.* XXIV.3, we find the line "*Sūryendu-Puliśa-Romaka-Vaśiṣṭha-Yavanādyaiḥ*", where we have a reference to all the then existing systems : *Sūrya-siddhānta*, *Indu-siddhānta*, *Puliśa-siddhānta*, *Vasiṣṭha-siddhanta*, and other *Yavana-siddhāntas*. Just as the Sun is one, so the astronomical system is also one ; this is a different thing that calculations in different systems may vary according to different sunrises in different places.

Brahmagupta refers at one place to Varāhamihira in *BrSpSi.* XXI.39, where he has been spoken of in connection with a list of

१. ब्रह्मणोक्तं ग्रहगणितं महता कालेन यत् खिलीभूतम् ।
अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन ॥ —*BrSpSi. I. 2.*

anti-authoritative versions of astronomical systems :

Evam Varāhamihira-Śrīṣenācāryabhaṭa-Viṣṇucandrādyaiḥ

Lokaviruddhamabhihitam Veda-smṛtisaṃhitābāhyam.

At one place, he mentions the difference between the calculations based on the system of Āryabhaṭa and the Pañca-siddhāntas (Five systems) : Pauliśa, Romaka, Vasiṣṭha, Saura, and Paitāmaha. (*BrSpSi*. XIV.46).

Brahmagupta was also familiar with the Jaina systems of astronomy; for example, at one place he uses the term "Jinoktam" (i.e., one propounded by the Jainas) : He repudiates the concept of *two Suns and two Moons* "*Dvāvarkaindavau*"(do canda do sujja) (*BrSpSi*. XI.3) as enunciated by the Jainas.

At several places we find a reference to the *Vaśiṣṭha-siddhānta* (*BrSpSi*. XI.49, 50; XXIV.3)

Wherever, Brahmagupta has to press for his views in preference to the views of others, he uses the words *Brāhma* or *Brahmokta* : *BrSpSi*.

Brāhma : I.32; X.62; XI, 61; XVI.37

Brahmokta : II.31, 33; X.63, 69; XV.59; XVI.38

Reference

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CHAPTER III

Manuscripts of the Brāhmasphuta Siddhānta

Sudhākara Dvivedī has given an account of some of the manuscripts of the *Brāhmasphuṭasiddhānta* in his *Bhūmikā* or Introduction appended to the edition published in the PAṆḌITA, Vol.XXIV, 1902 (New Series) : (i) available in the Library of the Government College, Kashi (Vārāṇasī) i. e. Kāśika-Rājakīya-Pāṭhālaya,(ii) Dr.Thibaut's Manuscript,(iii) the Manuscript in possession with Yajñadatta Sharmā, the Chief Astronomer attached to the Prince of Ayodhyā. It is further mentioned that Dr. Thibaut's Manuscript was a copy of a Manuscript available in the Deccan College, Poona. The Manuscripts (ii) and (iii) were identical. The Manuscripts (iii) was very faulty and incorrect.

The Manuscript from which Colebrooke translated out in English the Twelfth and the Eighteenth Chapters on *Gaṇita* or Mathematics and *Kuṭṭaka* (the Chapter on Pulveriser) respectively, appeared to be different from the three Manuscripts described above. The readings differed considerably. The *Kuṭṭaka*-Chapter of that book is, writes Sudhākara Dvivedī, still available in the India Office Library. (See Catalogue of the Sanskrit[1] Manuscripts in the Library of India Office, Part V.p. 995).[1]

1. एतत्कृतस्यास्य सिद्धान्तग्रन्थस्यैका प्रतिः काशिकराजकीय पाठालयतो द्वितीया डा० थिबौ साहिब महाशयतस्तृतीया चायोध्यानरेशप्रधानज्योतिर्विच्छ्री यज्ञदत्तशर्मणो मया लब्धा। डा० थिबौमहाशयस्य पुस्तकं कस्यचिद्दक्षिणदेशीय (Deccan College, Poona) डेका पुस्तकस्य प्रत्यन्तरम्। इदं पुस्तकं तथा पं० श्री यज्ञदत्त पुस्तकं चैकमातृकमेव। इदं पुस्तकत्रयमतीवाशुद्धं बहु च स्खलितं चास्ति।

यत्पुस्तकानुसारेण व्यक्ताध्याययोर्द्वादशाष्टादशसंख्ययोरंगलभाषायामनुवादः कोलब्रूकसाहिबेन कृतस्तत्पुस्तकमेतत्त्रयतो भिन्नमित्यसंशयं विभाति पाठविभेदात्। तत्पुस्तकस्य कुट्टकाध्यायः संप्रति इण्डिया-आफ़िस-सरस्वती भवने वर्तते (See Catalogue of the Sanskrit Manuscripts in the Library of India Office, Part V, Page 995)

पृथूदककृताऽस्य सिद्धान्तस्य टीका या कोलब्रूकसाहिबेन भारतवर्षे ह्युपलब्धा सा च संप्रति लण्डननगरे इण्डिया-आफिस-सरस्वती भवने वर्तते। तस्या एका प्रतिर्मद्द्वारेण श्री डा० थिबौ साहिबमहाशयेनोत्पादिता सापि संप्रति मन्निकटेऽस्ति। अहो इण्डिया-आफिस-सरस्वती

(Continued on next page)

Colebroke procured a Manuscript of the Pṛthūdaka Svāmī's Annotation on the *Brāhmasphuṭasiddhānta* from somewhere in India. This is also available in the India office Library, London. Undoubtedly it appears that this Manuscript is a copy from one written in the *Maithila* script. Dvivedī describes a few characteristics of this Manuscript. For example, on the Folio 11. 7 (७) is written instead of 9 (९). At a few other places also, the same has happened. Following a visarga, (*kva* क्व) is inscribed instead of '*ka*' (क), for example refer to Folio 12, line 6. At some places instead of *visarga* (:) we find ṣa (ष) inscribed, for example on Folio 12, line 1. Sometimes we find a *sandhi* at the *virāma* or end of a sententence ; e. g. in the Golādhyāya, Folio 21, line 2: *sarvamupapannamuktamakhaṇḍena* (सर्वमुपपन्नमुक्तमखण्डेन). At some places we find *nū* (नू) written in place of *nta* (न्त). In one of the Folios, *Śri Gaṇeśāya namaḥ.* श्रीगणेशायनमः is written in Maithila script.[1] Sudhākara Dvivedī prepared a copy of this Manuscript for Dr. Thibaūt, and this copy was available with Sudhākara Dvivedī when he published his commentary with Text in the *Paṇḍita.* During the course of binding, on account of carelessness, many of the Folios got misarranged, and many of them got fragmented. Sudhākara Dvivedī emphasises in his Introduction the need of careful research on the arrangement of these Folios and their readings. (See *Catalogue of the Sanskrit Manuscripts* in the Library of India Office, Part V, p. 993–995).

Sudhākara Dvivedī with considerable efforts could rearrange the Text :

Golādhyāya-Bhāṣyam 1 to 45, mutilated at the beginning
Madhyamādhikāra-Bhāṣyam 45 to 59

(Continued from previous page)

भवने अस्य पुस्तकस्य पुटकवन्धनकालेऽनवधानतया पत्राण्यसंगतानि जातानि, बहुत्र खण्डितानि च सन्ति । तानि कदाचिदनुपयुक्तपत्राणां मध्ये स्युरिति तेषां सम्यगन्वेषणं समुचितम् । (See Catalogue of the Sanskrit Manuscripts in the Library of India Office Part, V, Page 993-995)

1. इदं पुस्तक कस्यचिन्मिथिलाक्षरैर्लिखितस्य पुस्तकस्य प्रत्यन्तरमिति निःसंशयं प्रतिभाति । ११ पत्रे, ९ इत्यस्य स्थाने ७ इति लेखात् । एवमन्यत्रापि । विसर्गात् परतः 'क' स्थाने 'क्व' इति लेखात् । यथा १२ पत्रे, ६ पंक्तौ । तथा विसर्गस्थाने 'ष' इति लेखात् , यथा १२ पत्रे, १ पंक्तौ । वाक्यविरामेपि सन्धिकरणात् । यथा गोलाध्यायस्य २१ पत्रे, २ पंक्तौ सर्वमुपपन्नमुक्तमखण्डेन । कुत्रचित् 'न्त' स्थाने 'नू' इति लेखात् । एकस्मिन् पत्रे मैथिलाक्षरैः श्री गणेशायनमः इति लेखाच्च ।

In this, the commentary is up to verse 31. In the *Spaṣṭādhikāra*, the commentary begins from verse 29, Folio 60. At the top of the Folio, we have the old numbering 1 and 115.

After this, 68 folios are mis-arranged, and there the old numbering is marked 9.

After that, up to 87 folio, we have in the bound volume a commentary up to the verse 6 of *Tripraśnādhikāra*. Here the old numbering is marked 28. Then we have the commentary up to verse 27 of the *Tripraśnādhikāra*. Here the numbering of folios is marked 1 and 159 (old numbering) and 218 new. After this, then we have in the bound volume, commentary up to verse 33 of the Tripraśnādhikāra. On the last folio, the old numbering is marked 5 and 163, the new numbering 222. After this begins the commentary on the *Candragrahaṇādhikāra* from verse 4, old numbering 1 and 297 and new numbering 257. Then follows the commentary on *Sūryagrahaṇa* up to verse 23. The last old folio numbering is 36 and 232, the new numbering 292. This is the last folio-numbering of the volume in the India Office Library. After this, begins the commentary on *Grahayutyadhikāra*, verse 11, old numbering 1 and 164 and the new numbering 223.

Then follows the *Madhyagatyuttarādhyāya* up to verse 40, old folio numbering 119, and new numbering 178. Then we have the commentary of the *Madhyagatyuttarādhyāya* beginning from the verse 45; the old folio numbering 120 and the new numbering 179. Then we have the commentary on *Tripraśnottarādhyāya* up to verse 56. Here the last old folio number is 48 and 158, and the new numbering 217.

In this way, we have the commentary on : the multilated *Golādhyāya*, mutilated *Madhyamādhikāra*, mutilated *Spaṣṭādhikāra*, mutilated *Tripraśnādhikāra*, mutilated *Candra-grahaṇādhikāra*, mutilated *Sūrya-grahaṇādhikāra*, mutilated *Grahayutyadhikāra*, *Bhagrahayutyadhikāra*, *Tantra-parīkṣādhyāya* (also known as *Dūsaṇādhikāra*), *Gaṇitādhyāya* (Arithmetic), mutilated *Madhyagatyuttarādhyāya*, *Sphuṭagatyuttarādhyāya*, mutilated *Tripraśnottarādhyāya*.[1]

1. मया महताऽऽयासेन तत्प्रति-पाठक्रम एवं नियोजितः ।
गोलाध्यायभाष्यम् १-४५ आदौ खण्डितम् ।
मध्यमाधिकारभाष्यम् ४५-५६ ।

(Continued on next page)

Sudhākara Dvivedī says that nowhere in the *Brāhma-Sphuṭasiddhānta, Madhyamādhikāra,* is found the verse :

Saṁsādhya spaṣṭataram bījam nalikādiyantreṇa.
Tat-saṅsṛtagrahebhyaḥ kartavyau nirṇayādeśau.

(This verse has been quoted by Dvivedī in the *Gaṇaka-Taraṅgiṇī,* page 19).[1]

This verse has been quoted by Dvivedī from the Translation of *Grahalāghava* by Mallāri.

· Dvivedi further says that in the Manuscripts available, there is mentioned a Twenty-fifth Chapter under the title "*Dhyānagrahopadeśādhyāya*". Dvivedi thinks that this Chapter does not constitute the *Brāhmasphuṭasiddhānta* proper, which ends in fact with twenty-four chapters.[2] In his commentary and Edition in the *Paṇḍita,* he has published it as a separate treatise of Brahmagupta. Thus he has named his Edition as :

अत्र मध्यमाधिकारे ३१ श्लोकपर्यन्तमेव भाष्यम् ।

अतः स्पष्टाधिकारस्य २९ श्लोकतष्टीकाऽऽरब्धा ५० पत्रतोऽत्र प्राचीन संख्या पत्रोपरि १, तथा ११५ ।

अग्रेऽत्र ६८ पत्रमसंगतम् , यत्र प्राचीन संख्या ६ ।

ततः ८७ पत्रपर्यन्त संलग्नग्रन्थस्त्रिप्रश्नाधिकारस्य ६ श्लोकपर्यन्तं टीका । अत्र प्राचीनपत्रसंख्या २८। ततस्त्रिप्रश्नाधिकारस्य २७ श्लोकतष्टीका, पत्रसंख्या प्राचीना १ तथा १५९, नवीना २१८ । अग्रे संलग्न ग्रंथस्य त्रिप्रश्नाधिकारस्य ३३ श्लोकपर्यन्तं टीकान्तिमपत्रप्राचीनसंख्या ५ तथा १६३, नवीना संख्या च २२२। ततश्चन्द्रग्रहणाधिकारस्य ४ श्लोक टीकारब्धा प्राचीनपत्रसंख्या १ तथा २९७ । नवीना संख्या च २५७ । ततः सूर्यग्रहणस्य २३ श्लोकपर्यन्तं टीका । अन्तिम प्राचीन पत्र-संख्या ३६ तथा २३२, नवीना संख्या च २९२ । इण्डिया-आफिस पुस्तकपुटके चेयमन्तिमपत्रसंख्या । ततो ग्रहयुत्यधिकारस्य ११ श्लोकतष्टीकारब्धा यत्र प्राचीनपत्रसंख्या १ तथा १६४, नवीना संख्या २२३ । ततो मध्यमगत्युत्तराध्यायस्य ।

४० श्लोकपर्यन्तं संलग्नग्रन्थौ यत्रान्तिमप्राचीनपत्र संख्या ११९ नवीना संख्या च १७८ । ततो मध्यगत्युत्तराध्यायस्य ४५ श्लोकतष्टीकारब्धा । अत्र प्राचीनपत्रसंख्या १२० नवीनासंख्या च १७९ । ततस्त्रिप्रश्नोत्तराध्यायस्य ५६ श्लोकपर्यन्तं टीका । अत्रान्तिमप्राचीनपत्रसंख्या ४६ तथा १५८, नवीना संख्या च २१७ ।

खण्डितगोलाध्यायस्य । खण्डितमध्यमाधिकारस्य । खण्डितस्पष्टाधिकारस्य । खण्डित-त्रिप्रश्नाधिकारस्य । खण्डितचन्द्रग्रहणाधिकारस्य । खण्डितसूर्यग्रहणाधिकारस्य । खण्डितग्रहयुत्यधि-कारस्य । भग्रहयुत्यधिकारस्य । तन्त्रपरीक्षाध्यायस्य (दूषणाधिकारस्य) । गणिताध्यायस्य पाटीम-गणितस्य) । खण्डितमध्यगत्युत्तराध्यायस्य । स्फुटगत्युत्तराध्यायस्य । खण्डितत्रिप्रश्नोत्तराध्यायस्य च टीका वर्त्तते ।

1. सर्वेष्वपि पुस्तकेषु 'संसाध्य स्पष्टतरं बीजं नलिकादियंत्रेण' इत्यादिश्लोको मध्यमाधिकारे नास्ति । मया गणकतरंगिण्यां मल्लारिकृतग्रहलाघवटीकातो व्यलेखि (द्रष्टव्या गणकतरंगिणी पृ० -१८१९) ।

Brāhmasphuṭasiddhānto Dhyānagrahopadeśādhyāyaśca or *Brāhmaphuṭasiddhānta* and *Dhyānagrahopadeśādhyāya by* Brahmagupta (1902)[1]

The manuscript of this small treatise was also mutilated, and Dvivedī took special pains in editing it, and he revised the calculations also incorporated in this treatise.

The small treatise, *Dhyānagrahopadeśādhyāya* must have been composed prior to the *Brāhmasphuṭasiddhānta*, since we find a verse in the last Chapter (the 24th Chapter also known as the *Sañjñādhyāya* of the *Brāhmasphuṭasiddhānta)*, verse 9, a reference to this book :

How could this result be obtained in a simple way has been shown by me in the *Dhyānagrahopadeśādhyāya* of 72 Āryā verses, and therefore, it is not repeated here. *BrSpSi.* XXIV. 9)

In the *Dhyānagrahopadeśādhyāya*, we have a verse 61, which is also found in the *Khaṇḍakhādyaka* (KK. I. 21) :

Navatithayaḥ (159) divided by *aṣṭi* (16), pañcarasāḥ (65) divided by *vasu* (8), 10 divided by 3, each multiplied by the equinoctial shadow are the (tabular differences of) ascensional difference expressed in *vināḍis*. (*KK*. I. 21; *DhGr*. 61)

This verse then indicates that the *Dhyānagrahopadeśādhyāya* has been composed after the *Khaṇḍakhādyaka*. It may also be possible that the *Brāhmasphuṭasiddhānta* and the *Dhyānagrahopadeśādhyāya* were simultaneously written, and the above verse (*DhGr*. 61) was repeated again in the *Khaṇḍakhādyaka*.

Sudhākara Dvivedī has taken the help from the commentary of Pṛthūdaka Svāmī in the Chapters on *Pāṭigaṇita* (Arithmetic), and has quoted the examples from this commentary. At many places he has corrected the readings which were mutilated in manuscripts.

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1. उपलब्धमूलपुस्तकत्रये पंचविंशतितमेऽध्याये वस्तुतो ब्रह्मगुप्तकृतो ध्यानग्रहोपदेशाध्यायो वर्त्ततेऽतो मयायं पृथक्त्वेन तन्नाम्ना मुद्रितः । अत्र बहुत्र स्खलितानि पदानि तानि गणितेन संशोध्य मुद्रितान्यपि सुधीभिर्भृशं विचिन्त्यानि ।

अस्य सिद्धान्तस्य चतुर्विंशतितमेऽन्तिमे संज्ञाध्याये (पृ० ४०८)
गणितेन फले सिद्धिर्ब्राह्मे ध्यानग्रहे यतोऽध्याये ।
ध्यानग्रहो द्विसप्ततिरार्याणां न लिखितोऽत्र मया ॥

इति नवमश्लोकेन ध्यानग्रहोपदेशाध्यायस्य रचनेतत्सिद्धान्तरचनातः पूर्वं विभाति परन्तु तत्राहर्गणसाधनप्रकारेण सिद्धान्तरचनाकाल एवास्य रचना सिध्यति तथा 'नवतिथयोष्टिविभक्ता' इत्यादिपद्येन खण्डखाद्यरचनातः पश्चात् सिध्यति ।

Reference

Sudhākara Dvivedī : His *Bhūmikā* on *BrSpSi.*, *Paṇḍita*, Vol. XXIV, 1902 (New Series)

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Chapter IV

Subject Matter Classified in the Brāhmasphuṭasiddhānta & Khaṇḍakhādyaka

It needs no emphasis that Āryabhaṭa commanded a great influence as an astronomer not only prior to Brahmagupta but during his days also, and we have seen how Brahmagupta quoted this great authority in his writings, sometimes borrowing from him and sometimes contradicting him or improving upon his calculations. Āryabhaṭa's great work is known as the *Aryabhaṭīyam* written in 499 A. D. Āryabhaṭa was born in 476 A. D. (Kaliyuga Saṃvat 3577). The *Aryabhaṭīyam* is also known as the *Aryasiddhānta*. For details about Āryabhaṭa the reader is referred to the Chapter entitled "*Aryabhaṭa lays Foundations of Algebra*" (*Founders of Sciences in Ancient India*, 1965, Chapter X) . This great work was written in Kusumapura, (modern Patna, Bihar).

Divisions of Āryabhaṭiyam

The *Aryabhaṭīyam* is divided into four chapters called *Pāda*: (i) the *Gītikā Pāda*, with ten verses; (ii) the *Gaṇita Pāda* with 33 verses; (iii) the *Kālakriyā Pāda* with 25 verses and (vi) the *Gola Pāda* with 50 verses.

In the *Gaṇita Pāda*, a chapter on mathematics, we have such subjects : squares (*varga*), cubes (*ghana*) (verse 3), square-root (*vargamūla*) (4), cube-root (*ghanamūla*) (5) ; area of a triangle, volume of a prism (6), area of a circle, volume of a sphere (7), area of a quadrilateral (*viṣamacaturasra*) (8); circumference of a circle (10), Rsine (radius x sine) (*Jīvā*) (11); determination of the Rsine of the zenith distance, the base (*bāhu*) of a right-angled triangle, and the upright (*koṭi*) of a right-angled triangle (16) ; hypotenuse (*karṇa*) of a right-angled triangle and *ardhajyā* (17), Reversed-sine (*śara*) (18), areas of series-figures (*śreḍhīphala*) (19), rule of three (*trairāśika*) (23), reduction of fractions (*savarṇīkaraṇa* of *bhinna*) (27) ; inverse-rule of three (*vyasta*) (28) ;

evaluation of unknown values (*mūlya-pradarśana* of *avyakta mūlya* (30) ; and the theory of pulveriser (*Kuṭṭaka*) (32, 33). In this chapter, Āryabhaṭa gives the solutions of quadratic equations, and thus he earns for himself the credit of founding the science of algebra.

(iii) The *Kālakriyā Pāda* with 25 verses, which enumerates the units of time [1 year (*varṣa*)=12 months (*māsa*) ; 1 month=30 days (*divasa*) ; 1 day =60 *nāḍīs* ; 1 *nāḍī*=60 *vināḍī* ; *vināḍī* or *vināḍikā* is the same as *vighaṭikā* equivalent to our 24 seconds ; *nāḍī* or *nāḍikā* or *ghaṭī* is equal to 24 minutes][1] ; correlation of time division with the *kṣetra*—division or angular division,[2] Twelve signs of Zodiac or *rāśis* go to constitute a *bhagaṇa*[3] ; solar day (*ravimāsa*), lunar day (*śaśi māsa*) ; additional month or intercalary month (*adhimāsa*) ; various kinds of years : the solar year is human or *manuṣya* year ; 30 human years=1 *pitṛ* year ; 12 *pitṛ* years=1 *divya* year (divine year) ; 12,000 *divya* years constitute a *yuga* (6, 7, 8) ; the first half of the *yuga* is *utsarpiṇī kāla*, and the latter half is *avasarpiṇī kāla* and they are calculated from the apex of the Moon (*candrocca*) (this is not very clear) (9) ; a *yuga* is of 60 years, and such 60 *yugas*, that is 3,600 years had passed away since the *kaliyuga*, when the author was of 23 years of age, (10) ; the count of a *yuga*, year, month and

१. वर्षं द्वादशमासास्त्रिंशद्दिवसो भवेत् स मासस्तु ।
षष्टिर्नाड्यो दिवसष् षष्टिस्तु विनाडिका नाडी ॥

—*Ārya. III. 1.*

२. गुर्वक्षराणि षष्टिर्विनाडिकार्क्षी षडेव वा प्राणाः ।
एवं कालविभागः क्षेत्रविभागस्तथा भगणात् ॥

—*Ārya. III. 2.*

यावता कालेन षष्टिगुर्वक्षराण्युच्चरति मध्यमया वृत्त्या पुरुषः ।
तावान्काल आर्क्षी विनाडिका । ...यावता कालेन पुरुषः
षडुच्छ्वासान् करोति, तावान्कालश्चार्क्षी विनाडिका स्यात् ।

(परमादीश्वर)

Just as we have the time division, similarly we have the kṣetra division or the circular angular division. A year has twelve months, so do we have 12 *rāśi* in a *bhagaṇa*. One-thirtieth of a *rāśi* is one *bhāga* ; one-sixtieth of a *bhāga* is one *liptā* ; one-sixtieth of a *liptā* in one *viliptā* : and one-sixtieth of a *viliptā* is one *tatparā*.

३. चन्द्रोऽशैर्द्वादशभिरविक्षिप्तोऽर्कान्तरस्थितैर्दृश्यः ।
नवभिर्भृगुर्भृगोस्तैर्द्व्यधिकैर्यथाश्लक्ष्णाः ॥

—*Ārya. IV. 4.*

day should begin from the month *Caitra*, *Śukla Pratipadā* (the first day of the brighter half of the month *Caitra*) (11) ; *mandocca* (apex of slowest motion) and *śīghrocca* (apex of fastest motion) (17—24).

(iv) The *Gola Pāda* with 50 verses. In Verse 1, there is a reference to a point in the Sun's path, the commencement of *meṣa* (*meṣādi*) ; this must have been *vasanta*-equinox. The ascending nodes (*pāta*) of planets and the shadow of the Earth move on the path of the Sun (*arka-apamaṇḍala*) (2-3) ; the angular difference in relation to the Sun at the appearance of Moon (12 degree or *aṁśa*), of the Venus (9 degrees or 9 *vināḍikā*) ; of the Jupiter (2 more than the Venus, i.e. 11 *vināḍikās*) ; the Mercury or *Budha* (13 *vināḍikās*), of the Saturn or *Śani* (15 *vināḍikās*) ; and of Mars or *kuja* (17 *vināḍikās*).

The half of the Earth, Moon, planets and stars is dark, since those parts happen to be under their own shadow ; the other half is bright as it faces the Sun (this is not true with respect to stars—author) (5). The Earth is surrounded with an atmosphere of air and water (6, 7). In the *Brahma-Divasa* (Brahma's day), the sphere of the Earth is increased by one yojana and decreased by this amount during the Brahmā's night (8). Just as a person sitting on a moving boat sees the stationary trees etc. on the bank of a river moving in the opposite direction, similarly the stationary stars are seen moving from Laṅkā (or equator) moving towards the West(9). On account of *pravahavāyu* (air) the *nakṣatra* system and planets rise and set receding towards the West (10). The dimensions of *Sumeru Parvata* (North pole) is given to be one *yojana*, and it shines like a jewel (11) and in the next verse is given the position of Sumeru and the *Bāḍavamukha* (South pole) (12). The four cities situated at a difference of 90° each on the equator are given (13). The distance of Ujjayinī from Laṅkā (thus giving the latitude of Ujjayinī) is given (14).

On account of the thickness of the Earth-sphere, the *Khagola* (celestial sphere) is seen less than the hemisphere (15). The next verse describes how moving appears the Khagola on the North and South poles (16). Then is given the measure of day and night of *devas* (gods), *pitar* (fathers), *asura* (demons) and *manuja* (men) (17). Then are given a few technical definitions

of celestial mathematics (18—21) like *dṛṣṭi-sthāna* (intersection of horizontal and vertical axis--*pūrvapardiggatā rekhā* and *adha-ūrdhva-diggatā rekhā*). *Dṛṅ-maṇḍala*, *dṛgkṣepamaṇḍala* (*dṛgkṣepa* is the zenith distance of that point of a planet's orbit which is at the shortest distance from the zenith). Then the *Bhubhagola* instrument is described (22, 23). Then follow the formulæ for calculating *lagna* (the horizon ecliptic point in the East), *kala* etc. comprising the *Tripraśnādhikāra* (24—33). In the next verses, we have *lambaka* or Rsine of colatitude (34) ; *dṛk-karma* (35) and *ayana-dṛk-karma* (36). Then follow the calculations of lunar and solar eclipses (37—47). Verse 48 describes the coordinates of the Sun which are determined by the conjunction of horizon with the Sun, of the Moon by the conjunction of the Sun and the Moon, of planets by the conjunction of the Moon and planets or stars. Verse 49 describes how this jewel treatise has been procured out of an ocean of true and untrue knowledge with the help of a boat of intellect. This means that the author has taken special pains in discriminating true knowledge from falsehood with respect to the prevalent notions of astronomy. In the last verse he says, that he has not given anything new ; he has given that very knowledge which was imparted by the *Svayambhu* in the earliest times (50).

The *Pañchāṅgas* prepared according to the rules and formulæ of the *Āryabhaṭīyam* are still regarded with reverence by the *Vaiṣṇavas* in the South. Brahmagupta was a great critic of Āryabhaṭa, but finally he wrote his treatise, the *Khaṇḍakhādyaka*, on the basis of this very *Āryabhaṭīya* (this treatise is a *karaṇagrantha* i.e. one containing a principal element of the Indian Calendar). The four commentaries of the *Āryabhaṭīya* available in Sanskrit are of Bhāskara I, Sūryadeva Yajvā, Parameśvara and Nīlakaṇṭha. Two English translations by P.C. Senagupta (1927) and W.E. Clark (1930) are also available.

Major Landmarks

Indian astronomy which reached its zenith in the times of Āryabhaṭa and Brahmagupta shows its evolution in the following stages :

1. Rudiments of astronomy in the *Vedas* and *Brāhmaṇa* Books like the *Taittirīya Saṁhitā* and the *Śatapatha Brāhmaṇa*. This period is associated with the dis-

covery of the Vedic era, some of the planets, the twenty-four *nakṣatras*, cycle of seasons, concept of leap year, the dimensions of a yuga, solar and lunar years and the like.

II. Astronomy of the *Vedāṅga*, also known as the *Vedāṅga Jyotiṣ*. Lagadha is the most prominent figure ot this period (1400 B.C. to 850 B.C.) ; he is the first compiler of a text on astronomy. In his work, we for the first time in history find a reference to the *Jñeya Rāśi* (the knowable or the unknown quantity) and the *Jñāna-Rāśi* (known quantity). He lays the foundations of astronomical calculations. In his treatise we find a mention of such subjects as : Solstices (northern and southern journey of the Sun), increase in days and nights in the *ayanas* or solstices, solstitial *tithis* omission of *tithis*, *parva rāśi* , acceptable and non-acceptable *parvas*, addition of day, acceptable *parvas*, concept of *yoga* (a term applied to the joint space which would be travelled by the Sun and the Moon in a given period of time on the presumption that these two bodies have travelled in directions opposite to each other), method of finding out a *nakṣatra* on any *parva* day, distinction between *parva-nakṣatra* and *tithi-nakṣatra*, correlation of solar and lunar dates, measure of a *nāḍikā* (unit of time), *nakṣatra* of the Sun, *yoga* and its *nakṣatra*, *parva-bhaśeṣa* and equivalent *kalās*, solar year, lunar revolutions (risings of *nakṣatras*) deities of *nakṣtras*, lunar and *sāvana day* differences (*ahika māsa*), divisions of a *sāvana day* and length of day in two *ayanas*. This author probably belonged to Kashmir.

III. The period of *Siddhāntas* : Varāhamihira in his well known treatise, the *Pañcasiddhāntikā*, refers to five *Siddhāntas* or systems of Astronomy : Paitāmaha, Vasiṣṭha, Romaka, Pauliśa and Sūrya (Saura). As regards its importance, he gives the first place to the Sūryasiddhānta, places next the Romaka and Pauliśa, and declares the remaining two to be definitely inferior to the former. We do not possess the full treatise of these Siddhāntas, except the *Sūryasiddhānta*. Here too,

we have difficulty. The *Sūryasiddhānta*, as summarised by Varāhamihira in his *Pañcasiddhāntika*, in many essential features differs from the system prescribed by the Text of the *Sūryasiddhānta* now available. So we have two versions, the one with which Varāhmihira was familiar and the modern one.

The present *Sūryasiddhānta* comprises of fourteen chapters called *adhyāyas*. We have an authentic commetary on it by Parameśvara. The first two chapters of the *Sūryasiddhānta* have no special name. The classification of chapters is as follows :

Modern Sūrya Siddhānta

Chapter	Name of the Chapter	Number of verses	Subject
I	—	69	Mean longitude of planets.
II	—	68	True motion and true longitude of planet ; and elements of *Pañcāṅga.*
III	Tripraśnādhyāya	50	Directions, place and time.
IV	Candra-grahaṇādhyāya	29	Lunar eclipse.
V	Sūrya-grahaṇādhyāya	17	Solar eclipse.
VI	Chedyakādhyāya	24	Projection of eclipse on a plane surface.
VII	Graha-samāgama-yuddhādhyāya	24	Conjunction of one planet with another.
VIII	Tārāviṣayodhyāya	21	Conjunction of a Planet with the junction star of a nakṣatra.
IX	Udayāstamaya-viṣayodhyāya	18	Heliacal rising and setting of planets.
X	Candrāstamayādi viṣayāḥ	16	Moon rise and elevation of Moon-horn.
XI	Vyatipāta-viṣayāh	23	Pāta (*vyatipāta*)
XII	—	87	Cosmogony and geography

Chapter	Name of the Chapter	Number of verses	Subject
XIII	Vyatipāta-viṣayāh	26	Armillary sphere and astronomical instruments
XIV	—	28	Modes of reckoning time
	Total	500	

From the contents of the Modern *Sūryasiddhānta*, it appears that its great author (or rather *compiler*, since this *Siddhānta* has been existing much before he compiled this treatise) intends giving a complete but brief account of the entire Indian astronomy. He has been careful enough to avoid controversies, and he has omitted the methods occurring in other *Siddhāntas* and *Mahā-tantras* as alternative rules. He describes only those which are most important and of general nature. Part II of the book dealing with cosmogony and geography etc.. is very brief , a nd the entire subject has been summarised in three chapters (Chapters XII to XIV). The Chapter on Astronomical instruments (XIII) is sketchy and rather incomplete; the author has given the names only of the instruments, as if the purpose was to keep the details secret and guarded. The whole text of the *Sūryasiddhānta* is finished in 500 verses (compare this with the length of other Indian books on Astronomy: the *Brāhmasphuṭasiddhānta* 1008 verses, the *Siddhānta-śekhara* 890 verses and *Siddhānta-śiromaṇi* proper 962 verses).

The Modern *Sūryasiddhānta* is a composition or compilation of a period when the *Āryabhaṭīyam* and the *Brāhmasphuṭasiddhānta* had already become popular. This *Sūryasiddhānta* is indebted to both these systems, though it has nowhere acknowleged them in the Text. We shall refer to this matter later at an appropriate stage of our discussion.

It may casually be mentioned here that Alberuni has ascribed the authorship of the *Sūryasiddhānta* to Lāṭadeva while Munīśvara (603 A. D.) has ascribed it to Āryabhaṭa I. Though there is little or no support to these views, it is not improbable, that the works of Āryabhaṭa I and Lāṭadeva which followed midnight-day-reckoning were based on the *Sūryasiddhānta* prevalent at the time. P. C. Senagupta on the other hand is of the opinion that " the old *Sūryasiddhānta* was made up-to-date by Varāhamihira by replacing the old constants in it by new ones from Ārya-

bhaṭa I's midnight system. " In this connection, it must be remembered that Varāhamihira nowhere expresses his indebtedness to Āryabhaṭa I.

The *Sūryasiddhānta* undoubtedly is the most popular book on Astronomy in this country. It has been so for the last 1000 years as is seen from the list of commentators on its text (K. S. Sukla has given a list of 28 commentators including those who wrote commentaries in the South Indian languges like Telugu and Kannaḍa.) :

Allanarya Suri	Maheśvara
Amaredya	Mallikārjuna Sūri (1178 A. D.)
Bhaṭṭotpala (966 A. D.)	Nārāyaṇa
Bhūdhara (1572 A. D.)	Nrsinha Daivajña (b. 1586 A.)
Bhūti viṣṇu	Nṛsiṃhadeva
Caṅḍeśvara (1178)	Parameśvara (1432 A. D.)
Cola	Rāghava Śarmā (1592 A. D.)
Dādābhai (1719 A. D.)	Ramakṛṣṇa Ārādhya (1472 A. D.)
Devīdāsa	Raṅganātha (1603 A. D.)
Kamala Kara Daneśvarah (1618 A. D.)	Sārvabhauma
Kāmabhaṭṭa	Tamma Yajva (1599 A. D.)
Kṛṣṇa Daivajña	Yallaya (1472 A. D.)
Madanapāla	Viśvanātha (1628 A. D.)
Mādhavācārya	

A large number of astronomical books in this country were written on the basis of the *Sūryasiddhānta*, as the *Gaṇakānanda* by Sūrya (1387-1447 A. D.), *Gaṇitādarśa* by Dharmapathin, *Makaranda Sāriṇi* by Makaranda (1478 A D.), *Grahacakra* by Kucanācārya (1299 A.D.), *Viṣṇukaraṇa* by Viśṇu (1556 A.D.) besides many others with indefinite dates such as the *Sūryasiddhānta nayana-prakārah*, *Sūryasiddhānta-gaṇita Sūryasiddhānta-saṁgraha* by Viśvanātha Sūri, and Sūryasiddhānta Sāriṇi by Rāmadatta Daivajña. K. S. Sukla has given a list of this literature in his Introduction to the *Sūryasiddhānta*.

(iv) *Period of Bhāskara* I : The author or the compiler of the *Sūryasiddhānta* is not known nor its date of composition. Bhāskara and Brahmagupta are the brilliant names of a contemporary period. Bhāskara I lived in the seventh century of the Christian era and was a contemporary of Brahmagupta (628

A.D.). He wrote three works on Astronomy which were most likely composed in the following order : (i) the *Mahā-Bhāskarīya*. (ii) a commentary on the *Āryabhāṭīya*, and (iii) the *Laghu-Bhāskarīya*, His commentary on the *Āryabhātīya* was written in 629, i.e., only one year after the *Brūhmasphuṭasiddhānta*. His commentary on the *Āryabhatīya* was written in 629 A.D., i.e, one year after the completion of the *Brāhmasphuṭasiddhānta*. Undoubtedly Bhāskara was the follower of Āryabhaṭa I. Shukla says, that his works provide us with a detailed exposition of the astronomical methods taught by Āryabhaṭa I and throw light on the development of Astronomy in India during the sixth and early seventh centuries A. D. which was the most brilliant period in the history of Indian Astonomy-Shukla has brought a critical edition with English translation of the *Mahābhāskarīya* and the *Laghu-Bhāskarīya* and he proposes to bring out a volume on the life and works of this great astronomer,

Division of Mahābhāskarīya

The *Mahābhāskarīya* is divided into Chapters called the *adhyāyas*. The *adhyāyas* have not been named as some of the Chapters of the *Sūryasiddhānta* or the *Brāhmaspuhṭasiddhānta*. The number of verses in the *Mahābhāskarīya* is as follows :

	Subject	*Number of verses*
Adhyāya I	Mean Longitude of a Planet and Planetary Pulveriser	52
Adhyāya II	The Longitude Correction	10
Adhyāya III	Direction, Place and Time. Junction-stars of the Zodiacal Asterisms and conjunction of Planets with them.	75
Adhyāya IV	The Longitude of a Planet	64
Adhyāya V	Eclipses	78
Adhyāya VI	Rising, Setting and Conjunction of Planets	62
Adhyāya VII	Astronomical Constants	35
Adhyāya VIII	Examples	27

These titles to the subject-matter given in the above table have been assigned by Dr. Kripa Shanker Shukla in his critical

edition. The total mumber of verses in this work is 403. The Sūryasiddhānta has, as stated above, 500 verses in all.

Laghu-bhāskarīya

The *Laghu-Bhāskarīya* is also divided into eight chapters, each chapter is known as *Adhyāya.* The subject matter in the book has been dealt with as follows :

Subject			*Number of verses*
Adhyāya	I	Mean longitudes of the Planets	37
Adhyāya	II	True Longitudes of the Planets	41
Adhyāya	III	Direction, Place and Time from Shadow	35
Adhyāya	IV	The Lunar Eclipse	32
Ādhyāya	V	The Solar Eclipse	15
Adhyāya	VI	Visibility, Phases and Rising and Setting of the Moon	25
Adhyāya	VII	Visibility and Conjunction of the Planets	10
Ādhyāya	VIII	Conjunction of a Planet and a Star	19

The total number of verses in this text is 214. The *Laghu-Bhāskarīyam* is thus an abridged edition of the *Mahā-Bhāskarīyam.* From the closing stanza of this work, it is clear that the author wrote this work for the benefit of young students with immature mind by condensing and simplifying the contents of his larger work, the *Mahā-Bhāsarīyam* (also known as *Karma-nibandha*). Thus we have a little of the parallelism: Brahmagupta, after finishing his bigger treatise, the *Brāhma-sphuṭasiddhānta*, wrote a minor abridged work, the *Khaṇḍa-khādyaka*, as a *karaṇa grantha.* This latter work of Brahmagupta, however, incorporates some original ideas not included in the earlier work. Shukla has given an analytical table indicating the rules of the *Mahā-Bhāskarīyam* incorporated in the *Laghu-Bhāskarīyam* also in an abridged or modified form, and also a list of the rules which have been omitted in the *Laghu-Bhāsakrīya.* There are a few rules in the *Laghu-Bhāskarīya* also which have no counterpart in the

Mahā-Bhāskarīya. Shukla further says that the arrangement of the contents of the *Laghu-Bhāskarīya* is more systematic and logical than that of the *Mahā-Bhāskarīya*, and is, at the same time, in keeping with the general practice followed by the other Hindu astronomers. Numerous quotations of this work occur in the annotative works of Sūryadeva (b. 1191 A.D.), Yallaya (1480 A.D.), Nīlakaṇṭha (1500 A.D.), Raghunātha Rāja (1597 A.D.), Govinda Somayāji and Viṣṇu Śarmā and in the *Prayoga-racanā*, an anonymous commentary on the *Mahā-Bhāskarīyam*. We find the commentaries of this abridged work in Malayalam and Tamil also. All this speaks of the great popularity of this work.

There are circumstantial evidences to show that Bhāskara I had associations with the countries of Aśmaka and Surāṣṭra. His commentary on the *Āryabhaṭīya* was probably written in the city of Valabhī in Surāṣṭra. Perhaps Bhāskara I was born and educated in Aśmaka and later on he migrated to Valabhī, where he wrote his commentary on the *Āryabhaṭīya* or that he was a native of Valabhī and got his education in the Aśmaka country. Perhaps there was a strong school of Astronomy in the Aśmaka country, which was founded by the followers of Āryabhaṭa, so much so that at places, Bhāskara I has also called Āryabhaṭa as Āśmaka, his *Āryabhaṭīyam* by the name *Aśmaka-Tantra* or the *Āśmakīya* and the followers of Āryabhaṭa as Āśmakīyāḥ. This Aśmaka country or Aśmaka Janapada is mentioned in the Buddhist literature also. It was somewhere either in the north-west of India, or was situated between the rivers Narmadā and Godāvarī. Bhāskara I was evidently a resident of the latter Aśmaka (which was between the Narmadā and Godāvarī).

Brahamagupta and Bhāskara I were contemporaries. Both of them developed their systems in the earlier part of the seventh century A.D. (3700 years of *Kaliyuga*). *Brahāmasphuṭasiddhānta* was written in 628 A.D. and the commentary on the Āryabhaṭīyam by Bhāskara I was composed in 629 A. D. Bhāskara closely followed Āryabhaṭa, but Brahmagupta had the guts to oppose the views expressed by this great master and he not only contradicted him at places, but also propounded many new ideas, methods of calculation and constants of greater accuracy.

The classification of the contents of Astronomy in *adhikāras* appears to be the original concept of *Brahmagupta* ; this system was to some extent adopted in the modern *Sūrya-Siddhānta* in the case of a few chapters. The *Vaṭeśvara-Siddhānta* by Vaṭeśvarācārya (born 802 Śaka or 880 A.D. in Ānandapura city, Punjab, son of Mahādatta) also adopts the terminology: *Madhyamādhikāra, Spaṣṭādhikāra* and *Tripraśnādhikāra.* We owe this type of caption-nomenclature to Brahmagupta.

Contents of the Brahmasphuṭasiddhānta

Now we shall summarise the contents of the Chapters of this great treatise and also enumerate the number of verses in each chapter. The author has himself given the total number of verses in the Chapter in the ending verse of each chapter. Sometimes, the verse specifying this number itself is not taken into account while giving the total number of verses in that chapter, and therefore, there occurs a minor discrepancy in the actual number and the number specified by the author himself. The following table records both these numbers separately :

Chapter	Title	Number of verses indicated by the author	Actual number of verses
	PŪRVA-DAŚĀDHYĀYI (First Ten Chapters)		
I	Madhyāmadhikāraḥ (Madhyamagati-radhyāyaḥ)	63	63
II	Spaṣṭādhikāraḥ (Sphuṭagati-radhyāyaḥ)	67	68
III	Tripraśnādhikāraḥ (Tripraśnādhyāyaḥ)	66	66
IV	Candragrahaṇādhikāraḥ (Candragrahaṇādhyāyaḥ)	20	20
V	Sūryagrahaṇādhikāraḥ (Ārka-grahaṇam or Ravigrahaṇādhyāyaḥ)	26	27
VI	Udayāstādhikāraḥ (Udayāstamayādhyāyaḥ)	12	13

VII	Candraśṛṅgonnatyadhikāraḥ (Candraśṛṅgonnati-adhyāyaḥ)		18	18
VIII	Candracchāyādhikāraḥ (Candracchāyā-adhyāyaḥ)		9	9
IX	Grahayutyadhikāraḥ (Grahamelanādhyāyaḥ)		26	26
X	Bhagrahayutyadhikāraḥ (Bhagrahayutiḥ-adhyāyaḥ)		70	70
	Total (of Daśādhyāyī)		377*	380*
XI	Tantra-Parīkṣādhyāyaḥ (Dūṣaṇādhyāyaḥ)		63	63
XII	Gaṇitādhyāyaḥ			
	Miśraka-vyavahāraḥ	1—16		
	Śreḍhī-vyavahāraḥ	17—20		
	Kṣetra-vyavahāraḥ	21—39		
	Vṛttakṣetra-gaṇitam	40—43		
	Khāta-vyavahāraḥ	44—46		
	Citi-vyavahāraḥ	47—		
	Kākacika-vyavahāre karaṇasūtre	48—49		
	Rāśi-vyavahāraḥ	50—51		
	Chāyā-vyavahāraḥ	52—66	66	66
XIII	Praśnādhyāyaḥ (Madhyagatyuttarādhyāyaḥ)		49	48
XIV	Sphuṭagatyuttarādhyāyaḥ		54	55
XV	Tripraśnottarādhyāyaḥ		60	60
XVI	Grahaṇottarādhyāyaḥ		46	47
XVII	Sṛṅgonnatyuttarādhyāyaḥ		10	10
XVIII	Kuṭṭādhyāyaḥ (Kuṭṭakādhyāyaḥ)		103	102
	Kuṭṭākāraḥ	1—29		
	Dhanarṇa-śūnyānām saṃkalanam	30—42		
	Ekavarṇa.samīkaraṇa-bījam	42—50		
	Anekavarṇa-samīkaraṇa-			

	bījam	51—59		
	Bhāvita-bījam	60—63		
	Varga-prakṛtiḥ	64—74		
	Udāharaṇāni	75—102		
XIX	Śaṅkucchāyādijñanādhyāyaḥ		20	20
XX	Chandaścityuttarādhyāyaḥ		20	19
XXI	Golādhyāyaḥ		70	70
	Sāmānya-golaprakaraṇam	1—16		
	Jyā-prakaraṇam	17—23		
	Sphuṭagati-vāsanā	24—30		
	Bimba-sādhanam	31—35		
	Grahaṇa-vāsanā	36—48		
	Golabandhādhikāraḥ	49—70		
XXII	Yantrādhyāyaḥ		53	57
XXIII	Mānādhyāyah		12	12
XXIV	Sañjnādhyāyaḥ		13	13
		Total	1016	1022

In one of the verses, Brahmagupta states that he has composed the treatise containing 1008 verses. Sudhākara Dvivedī has given the total as 1021, whereas he says, this number according to Brahmagupta's own statement should be 1020. If one deducts the concluding 12 verses of the *Sañjñanādhyāya*, the number should be 1008.

Sudhākara Dvivedī, in his addition of the *Brāhma-sphuṭa-siddhānta* (published in the *Paṇḍita*, 1901 and 1902) gives as a supplement a small treatise of Brahmagupta known as *Dhyāna-grahaṇopadeśādhyāya* or *Dhyānagrahaṇādhikāraḥ* which has 72 verses.

It would be worthwhile to give here the details of the *Khaṇḍakhādyaka* also, a book of Brahmagupta about which we have spoken so much. The titles to the chapters have not been indicated in the Text; most likely they have been assigned by the commentator, Pṛthūdaka Svāmī known as the *Khaṇḍakhādyaka-vivaraṇam.*

Chapter	Title	Number of verses
I	Tithi-nakṣatrādhikārādhyāyaḥ (On tithīs, nakṣatras etc.)	32
II	Grahagatyadhyāyaḥ (On the mean and true places of 'star' planets)	19
III	Tripraśnādhyāyaḥ (On the three problems relating to diurnal motion)	16
IV	Candragrahaṇādhyāyaḥ (On lunar eclipses)	7
V	Sūryagrahaṇādhyāyaḥ (On solar eclipses)	6
VI	Udayāstādhikāraḥ (On the rising and setting of planets)	7
VII	Candraśṛṅgonnatyadhāyaḥ (On the position of the Moon's cusps)	4
VIII	Samāgamādhyāyaḥ (On conjunction of planets)	6
	UTTARA KHAṆḌAKHĀDYAKA—APPENDIX	
IX	Corrections and new methods	14
X	On conjunction of stars and planets	16
	Total	127

Bhaṭṭotpala, in his commentary on the *Khaṇḍakhādyaka* has given several additional verses in the main or proper treatise and also in its Uttara portion or the Appendix. P.C. Sengupta's edition (Sanskrit Text 1941) has given at the end of this publication the account of these additional verses. The English

edition (1934) classifies the *Uttara-Khaṇḍakhādyaka* into two chapters (which the author calls as Chapters IX and X), the Sanskrit edition gives 3 verses in Chapter IX, 21 verses in Chapter X and 24½ verses in Chapter XI. Of these three chapters, the Chapter X has been given the title "*Paṭādhikāra*" and Chapter XI the title "*Parilekhādhyāya*" by Bhaṭṭotpala.

TABLE

Arrangement of contents in different treatises

Topic	*BrSpSi*	*SūSi*	*MBh*	*MSi*	*SiŚe*	*SiŚi*
Mean longitudes of the planets	I,XIII	I	I	I,II	I,II	I
True longitudes of the planets	II,XIV	II	IV	III	III	II
Direction, place and time	III,XV	III	III	IV	IV	III
Computation of a lunar eclipse	IV,XVI	IV	V	V	V,VII	IV,V
Computation of a solar eclipse	V,XVI	V	V	VI	VI	VI
Projection of an eclipse	XVI	VI	V	VIII		V
Conjunction of a planet with another planet	IX	VII	VI	XI	XI	X
Conjunction of a planet with a star	X	VIII		XII	XII	XI
Heliacal rising of planets	VI	IX	VI	IX,X	IX	VII, VIII

Topic	*BrŚpSi*	*SūSi*	*MBh*	*MSi*	*SiŚe*	*SiŚi*
Moonrise and elevation of lunar horns	VII, XVII	X	VI	VII, VIII	X	IX
Pāta	XIV	XI	VII	XIII	VIII	XII
Cosmogony and geography	XXII	XII		XVI		II.iii
Astrono. instruments	XXIII	XIII	III		XIX	II.xi
Time reckoning	XXIV	XIV				I.i

Āryabhaṭa and Brahmagupta Controversy

The scientific Indian astronomy was more or less created by Āryabhaṭa I (476 A. D.). It is said that he was the teacher of two distinct systems of astronomy, one of which is called the *audayika* system, and the other the *ardharātrika* system. In the first, the astronomical day is taken to begin at *sunrise* at Laṅkā, and in the other, the same begins at the *midnight* of the same place. In the *Khaṇḍakhādyaka* Brahmagupta gives compendious rules for the calculation of longitudes, etc, of planets according to the *ardharātrika* system of Āryabhaṭa I. In this connection, he refers to Āryabhaṭa in the following words in his *Khaṇḍakhādyaka* :

> Having made obeisance to God Mahādeva, who is the great cause of this world's rise (i. e. creation), existence, and destruction, I shall declare the *Khaṇḍakhādyaka* which will yield the same results as the great astronomical treatise of Āryabhaṭa.[1]

> As in most cases calculation by the great work of Āryabhaṭa, for (the knowledge of time and longitude of planets etc. at) marriage, nativity and the like is impracticable for common use every day, this smaller

1. प्रणिपत्य महादेवं जगदुत्पत्तिस्थितिप्रलयहेतुम् ।
वक्ष्यामि खण्डखाद्यकमाचार्य्यार्य्यभटतुल्यफलम् ॥

treatise (i.e. *Khaṇḍakhādyaka*, literally meaning food prepared from sugar-candy) is made so as to yield the same results as that.[1]

The mean saturn diminished by 3 seconds, the *Śighrocca* of Mercury diminished by 22 seconds, the mean Mars increased by 2 seconds and the mean Jupiter increased by 4 seconds are equal to the respective mean planets of Āryabhaṭa's *midnight* system.[2]

In the *Brāhmasphuṭasiddhānta*, Brahmagupta accepts the astronomical day to begin with the sunrise at Laṅkā, and the calculations of days, months, years, Yugas, and Kalpas all begin from Caitra Śukla Pratipadā (the first *tithi* of the month Caitra in the bright-half of the Moon) and the first day is regarded as Sunday.[3]

Varāhamihira in his epicyclic cast to the *Sūryasiddhānta* in his *Pañcasiddhāntikā* adopts the *ardharātrika* system or the system of reckoning days from midnight. The question why Brahmagupta who was so bitter an opponent of Āryabhaṭa I in his younger days (628 A.D.) claimbed down to describe and teach one of the systems of Āryabhaṭa's astronomy in his sixty-seventh year (665 A.D.) is difficult to explain. In fact so great was Āryabhaṭa's reputation and fame that in spite of Brahmagupta's severe ricticisms of the former in Chapter XI of the *Brāhmasphuṭasiddhānta*, it perhaps was undiminished and it was Āryabhaṭa who continued to be universally followed.

Some authorities have thus expressed the view that to meet the popular demand Brahmagupta in the *Khaṇḍakhādyaka* took upon himself the task of simplifying Āryabhaṭa's *ardharātrika* system and in this task he became eminently successful. But it has been supposed that in this task he could not be a mere simplifier or expounder.

प्रायेणार्य्यभटेन व्यवहारः प्रतिदिनं यतोऽशक्यः ।
उद्वाहजातकादिषु तत्समफल लघुतरोक्ति रतः ॥

त्रिसृभिः शनिर्ज्ञशीघ्रं द्वाविंशत्या कुजोऽधिको द्वाभ्याम् ।
चतसृभिरधिको जीवोऽर्द्धरात्रिकार्य्यभट मध्य समाः ॥

—*KK*. I. 1,2,7

3. चैत्रसितादेरुदयाद्भानोर्दिनमासवर्षयुगकल्पाः ।
सृष्ट्यादौ लंकायां समं प्रवृत्तः दिनेऽर्कस्य ॥

—*BrSpSi I.4*

The minor work of Brahmagupta known as *Khaṇḍakhādyaka* has two distinct parts : *Khaṇḍakhādyaka* proper and the *Uttara Khaṇḍakhādyaka.* In the first part the astronomical constants are the same as those of Āryabhaṭa's *ardharātrika* system, but the methods of spherical astronomy, calculation of eclipses and other topics are almost the same as in the *Brāhmasphuṭasiddhānta.* The corrections for parallax in calculating a solar eclipse is here an important illustration.[1]

In the *Uttarakhaṇḍakhādyaka*, Brahmagupta gives corrections to the *Khaṇḍakhādyaka* proper. In it are to be found the neat and original methods of interpolation and correction to the longitudes of the aphelia, as also to the dimensions to the epicycles of apsis of the Sun and the Moon.[2] while a few additional chapters supply what else is necessary to the first seven chapters of the first part, to make the whole a complete treatise on Indian scientific astronomy. It was perhaps through the influence of this supplementary part of the *Khaṇḍakhādyaka* that Brahmagupta's great work, the *Brāhmasphuṭasiddhānta* came to be valued among a distinct school of Indian astronomers. For long in this country India, this *Siddhānta* of Brahmagupta has been forming the basis for the calculation of almanacs by astronomers of the orthodox school of Rājasthān, Bombay and others.

We might at this stage take up the question : Was Āryabhaṭa the author of two distinct systems of astronomy ? Undoubtedly he was. Several authors have written on this subject. I may specially mention the name of Prabodha Chandra Sengupta (*Journal of the Department of Letters*, Calcutta University, vol. XVIII; *Bulletin, Calcutta Mathematical Society*, vol. XXII. Nos. 2 and 3). The reasons advanced by him may be restated in slight details thus. In his *Brāhma-*

1. व्यासार्धेन विभक्ता दृग्गतिजीवा चतुर्गुणा लब्धम् ।
लम्बननाडयः पञ्चदश गुणितया त्रिज्यया भक्ता ॥
दृक्क्षेपज्या भुक्त्यन्तरा हता लब्धमवनतिर्भवति ।
स्फुटयोजनकर्णाभ्यां भूव्यासेन च विना स्पष्टे ॥
आर्यभटेनास्मिन् सति लघुनि किमर्थं महत् कृतं कर्म ।
गणिताज्ञानाज् जाड्यं विजानता यदि ततः सुतराम् ॥

—*BrSpSi.* XI. 23-25, also *KK.* V.

2. See UKK. 9.

sphuṭasiddhānta, Brahmagupta thus speaks of the two works of Āryabhaṭa:

> As in both the works the number of the Sun's revolutions is spoken of as 432,000 years, their planetary cycle is clear, i. e., of 4,320,000 years. Why then is there difference of 300 civil days in the same cycle of the two books ?[1]

Again, he says :

> In 14,400 years elapsed of the *Mahāyuga*, there is produced a difference of one day in the *audayika* and *ardharātrika* systems.[2]

Varāhamihira in the *Pañcasiddhāntikā* writes ·

> Āryabhaṭa maintains that the beginning of the day is to be reckoned from midnight at Laṅkā; and the *same* teacher again says that the day begins from sunrise at Laṅkā. [3]

Thus from the writings of Brahmagupta and Varāhamihira, it is clear that Āryabhaṭa I was the author of both the *audayika* and *ardharātrīka* systems of astronomy. In Varāhamihira's verse the phrase *sa eva* (स एव), meaning "he undoubtedly" is of speeial significance. It removes the least doubt as to Āryabhaṭa's authorship of both these systems. The *audayika* and *ardharātrika* astronomical constants are respectively to be found from the Āryabhatīya and may be deduced from the *Khaṇḍakhādyaka* as well. The following is the comparative view of the constants of Varāhamihira and of the present day *Sūryasiddhānta.*

TABLE I

Planetary revolutions in a mahāyuga of 4,320,000 years, according to various authorities.

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1. युगरविभगणाः रव्युद्यति यत् प्रोक्तं तत् तयोर्युगं स्पष्टम् ।
त्रिशती रव्युदयानां तदन्तरं हेतुना केन ॥

—*BrSpSi XI. 5*

2. अधिकैः शतैश्चतुर्भिर्वर्षं सहस्रैश्चतुर्दशभिरेकः ।
युगयातैर्दिनवारान्तर मौदयिकार्धं रात्रिकयोः ॥

—*BrSpSi XI. 13*

3. लङ्कार्द्धरात्रसमये दिनप्रवृत्तिं जगाद चार्यभटः ।
भूयः स एव सूर्योदयात् प्रभृत्याह लङ्कायाम् ॥

—*PSi. XV. 20*

Planet	*BrSpSi*	*Āryabhaṭīya*	*Khaṇḍa-khādyaka*	Varāha-*Sūrya-siddhānta* (PSi.)	Later or modern *Sūrya-siddhānta*
Moon	57,753,300	57,753,336	57,753,336	57,753,336	57,753,336
Sun	4,320,000	4,320,000	4,320,000	4,320,000	3,320,000
Mars	2,296,828.522	2,296,824	2,296,824	2,296,824	2,296,832
Jupiter	364,226.455	364,224	364,220	364,220	364,220
Saturn	146,567.298	146,564	146,564	146,564	145,568
Moon's apogee	—	488,219	488,219	488,219	488,203
Venus	7,022,389.492	7,022,338	7,022,388	7,022,388	7,022,376
Mercury	17,936,998.984	17,937,020	17937,000	17,937,000	17,937.060
Moon's nodes	232,311.168	232,226	232,226	232,226	232,238

TABLE II

Longitudes of the apogees of the orbits of Planets.

Planets	*Āryabhaṭīya*	*Khaṇḍa-khādyaka*	Varāha *Sūrya-siddhānta.*	Modern *Surya-siddhānta*
Sun	78°	80°	80°	77° 07′
Mercury	210°	220°	220°	220° 26′
Venus	90°	80°	80°	79° 49′
Mars	118°	110°	110°	130° 00′
Jupiter	180°	160°	160°	171° 16′
Saturn	236°	240°	240°	236° 37′

TABLE III

Dimensions of the epicycles of Apsis

Planets	*Ārybhaṭīya*	*Khaṇḍa-khādyaka*	Varāha. *Sūrya-siddhānta*	Modern *Sūrya-siddhānta*
Sun	13°-30′	14°	14°	$13\frac{2}{3}$°-14°
Moon	31°-30′	31°	31°	$31\frac{2}{3}$°-32°
Mercury	$22\frac{1}{2}$°-$31\frac{1}{2}$°	28°	28°	28°-30°
Venus	9°-18′°	14°	14°	11°-12°
Mars	63°-81°	70°	70°	72°-75°
Jupiter	$31\frac{1}{2}$-$36\frac{1}{2}$°	32°	32°	32°-33°
Saturn	$40\frac{1}{2}$-$58\frac{1}{2}$	60°	60°	48°-49°

Table IV

Dimensions of the Śīghra epicycles (i.e. conjunctions)

Planet	*Āryabhaṭīya*	*Khaṇḍa-Khādyaka*	Varāha *Sūrya-siddhānta*	Modern *Sūrya-siddhānta*
Saturn	36½°- 40°	40°	40°	39°- 40°
Jupiter	67½°- 72°	72°	72°	70°- 72°
Mars	229½°-239½°	234°	234°	232°-235°
Venus	256½°-265½°	260°	260°	262°-262°
Mercury	130½°-139½°	132°	132°	132°-133°

Table V

Longitudes of the nodes of the orbits of planets

Planets	*Āryabhāṭīya*	*Khaṇḍa-khādyaka siddhānta*	Varāha *Sūrya-siddhānta*	Modern *Sūrya-siddhānta*
Saturn	40°	40°	Not stated	Have to be
Jupiter	20°	20°	in the	calculated
Mars	80°	80°	Text	from the
Venus	60°	60°		data of the
Mercury	100°	100°		text

Table VI

Orbital inclinations (geocentric) to the ecliptic

Planets	*Āryabhatīya*	*Khaṇḍa-khādyaka*	Varāha *Sūrya-siddhānta*	Modern *Sūrya-siddhānta*
Mars	90′	90′	10′	90′
Mercury	120′	120′	135′	120′
Jupiter	60′	60′	101′	60′
Venus	120′	120′	101′	120′
Saturn	120′	120′	135′	100′

The *Mahābhāskarīya* of Bhāskara I (522 A. D.) contains a passage which corroborates the fact that Āryabhaṭa I was the author of both the *audayika* and the *ardharātrika* systems of Indian Astronomy. According to Pṛthūdakasvāmin, whose

commentary on the *Brāhmasphuṭasiddhānta* we have the privilege of presenting to the public, it is clear that in certain respects Bhāskara and others may be wrong but the Āryabhaṭa's authenticity cannot be questioned. Pṛthūdakasvāmin while commenting on the *Brāhmasphuṭasiddhānta*, XI. 26 writes:

> Such a mistake may have been made by Bhāskara and others; they have not understood his (Āryabhaṭa's) intention.

The passage in the *Mahābhāskarīya* giving constants of the *ardharātrika* system runs as follows (we are giving the translation from Kripa Shankar Shukla's edition on the *Mahābhāskarīya*) :

> The astronomical processes which have been set forth above come under the sunrise day - reckoning (*audayika* system). In the midnight day-reckoning (*ardharātrika* system) too, all this is found to occur: the difference that exists is being stated (below). [1]

The next fourteen stanzas relate to the midnight day-reckoning of Āryabhaṭa I.

(i) Civil days and omitted lunar days in a *yuga* and revolution numbers of Mercury and Jupiter are thus given :

(To get the corresponding elements of the midnight day-reckoning) add 300 to the number of civil days (in a *yuga*) and subtract the same (number) from the number of omitted lunar days (in a *yuga*); and from the revolution numbers of (the *śīghrocca* of) Mercury and Jupiter subtract 20 and 4 respectively. [2]

Thus according to the midnight day-reckoning, we get

civil days in a *yuga*	=	1,577,917,800
omitted lunar days in a *yuga*	=	25,082,280
revolution number of the *śighrocca* of Mercury	=	17,937,000
revolution number of Jupiter	=	364,220

1. निबन्धः कर्मणां प्रोक्तो योऽसावौदयिको विधिः ।
अर्धरात्रे त्वयं सर्वो यो विशेषः स कथ्यते ॥ —*MBh. VII. 21*

2. त्रिशती भूदिने क्षेप्या ह्यवमेभ्यो विशोध्यते ।
ज्ञ गुर्वोर्भगणेभ्योऽपि विंशतिश्च ततोऽब्धयः ॥ —*MBh. VII. 22*

(ii) Diameters of the Earth, the Sun and the Moon are thus given :

(In the midnight day-reckoning) the diameter of the Earth is (stated to be) 1,600 *yojanas;* of the Sun 6,480 (*yojanas*) and of the Moon, 480 (*yojanas*)[1].

(iii) Mean distances of the Sun and the Moon are as follows :

The (mean) distance of the Sun is stated to be 689,358 (*yojanas*), and of the Moon 51,566 (*yojanas*).[2]

(iv) Longitudes of the apogees of the planets are as follows: 160, 80, 240, 110, and 220 are in degrees the longitudes of the apogees of Jupiter, Venus, Saturn, Mars and Mercury respectively.[3]

(v) *Manda* and *Śighra* epicycles of the planets are as follows :

The *Manda* epicycles (of the same planets) are 32, 14, 60, 70, and 28 (degrees) respectively; and the *Śighra* epicycles are 72, 260, 40, 234, and 132 (degrees) respectively. The Sun's apogee and epicycle are the same as those of Venus (i. e. 80° and 14° respectively).

The Moon's epicycle in the midnight day-reckoning is stated to be 31 (degrees). [4]

(vi) The positions of the so called *manda* and *śighra pātas* of the planets are given below:

(The following directions for) the degrees of the (*manda* and *śighra*) *pātas* of the planets as devised

---

1. अष्टिश्शतगुणा व्यासो योजनानां भुवो रवेः ।
खाष्टाब्ध्यङ्गानि शीतांशोः शून्यवस्वब्धयस्तथा ॥ —23

2. वस्विन्द्रिय गुणच्छिद्रवस्वङ्गानि विभावसोः ।
अङ्गाङ्गेष्वेक भूतानि चन्द्रकर्णः प्रकीर्तितः ॥ —24

3. अष्टिरष्टौ जिनारुद्रा विंशतिर्द्व्यधिकाः क्रमात् ।
दशाघ्ना गुरुशुक्रार्कि भौमज्ञांशाः स्वमन्दजाः ॥ —25

4. मन्दवृत्तानि द्वात्रिंशन्मनवः षष्टिरेव च ।
खाद्रयो वसुदस्राः स्युः शीघ्रवृत्तान्यथ क्रमात् ॥ —26
द्व्यद्रयः खाङ्गनेत्राणि खाब्धयोऽब्ध्यग्निदस्रकाः ।
द्व्यग्नीन्दवो रवेर्मन्दं शुक्रवद् वृत्तमेव च ॥ —27
एकत्रिंशत्तपाभर्तुरर्धरात्रे विधीयते । —MBh. VII 26-28 (i)

> (under the midnight day-reckoning) should be noted carefully by learned scholars :
>
> Add 180° to the longitudes of the *mandoccas* (apogees) apd *śīghroccas* of Mercury and Venus, and subtract 3 signs from the *mandoccas* (apogees) and *śīghroccas* of the remaining planets. Then are obtained the longitudes of the *manda* and *śīghra pātas* of the planets. (Also) add 2 degrees to the longitudes of the *manda pātas* and *śīghroccas* of Venus, Saturn and Jupiter, and $1\frac{1}{2}$ degrees to those of Mars and Mercury. (It should be noted that) the *śīghra pātas* have been stated for all the planets excepting Mercury. (Mercury does not have a *śīghra pāta*).[1]

That is to say, the longitudes of the *manda pātas* of Mars, Mercury, Jupiter, Venus, and Saturn are 21.5, 41.5, 72, 262 and 152 degrees respectively; and the longitudes of the *sīghra pātas* of Mars, Jupiter, Venus and Saturn are (*sīghrocca*−88.5°), (*sīghrocca* −88°), (*śīghrocca*+182°) and (*sighrocca*−88°) respectively.

(vii) A rule for finding the celestial latitude of a planet is as follows :

> (From the longitude of a planet severally) subtract the longitudes of its (*manda* and *śighra*) *pātas* and therefrom calculate (as usual) the corresponding celestial latitude of that planet. Add them or take their difference according as they are of like or unlike directions. Then is obtained the true celestial latitude of that particular planet. The true celestial latitude of any other planet is also obtained in the same way. The remaining (astronomical) determinations are the same as stated before. This all is in brief the difference of the other *tantra* (embodying the midnight day-reckon-

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1. पातभागाश्च विज्ञेयाः पण्डितैः परिकल्पिताः ॥ —*28*
मन्द शीघ्रोच्चयोः क्षेप्यं चक्रार्धं बुधशुक्रयोः ।
राशित्रयं तु शेषाणां पात्यते पातसिद्धये ॥ —*29*
शुक्रार्किदेव पूज्यानां भागौ द्वावेव संयुतौ ।
मन्दपाताच्च शीघ्रोच्चात् सार्धांशस्तु कुजज्ञयोः ॥ —*30*
विबुधानां च सर्वेषां शीघ्रपाताः प्रकीर्तिताः । *MBh. VII. 28 (ii) 31 (i)*

ing of *Āryabhaṭa* I).[1]

(viii) A rule for finding the longitude of the true mean planet according to midnight-day reckoning is as follows :

Apply half the *Śighraphala* and (then) half the *mandaphala* to the longitude of the planet's own *mandocca* (reversely).

From the resulting longitude of the planet's *mandocca* calculate the (*mandaphala* and apply it to mean longitude of the planet : the resulting longitude of planet is stated to be) the true-mean longitude of the planet. This is stated to be another difference (of the midnight day-reckoning) [2]

(ix) Length of the circle of the sky and derivation of the lengths of the orbits of the planets are given as follows :

Multiply the revolutions of the Moon (in a *yuga*) by 3, 240,000 and then discard the zero in the unit's place : (this is the length of the circle of the sky in terms of *yojanas*). (Severally) divide that by the revolutions of the planets (in a *yuga*): thus are obtained the lengths of the orbits of the respective planets in terms of *yojanas*.[3]

From these stanzas (from 20-35), it is evident that one *yojana* of the sunrise day-reckoning is one and a half times that of the midnight day-reckoning.

Now from stanza 22, it appears that 300 is to be added to the number of civil days in a *Mahāyuga*. According to the *Āryabhaṭīya*. the number of civil days in this cycle is 1,577,917, 500, which increased by 300, becomes 1,577,917,800, the number of

1. शोधयित्वा क्रमात् पातान् विक्षेपांशान् प्रसाधयेत् । —*31*
योगविश्लेषनिष्पत्तिरेकानेकस्वदिग्वशात् ।
विक्षेपः स स्फुटो ज्ञेयो ग्रहस्यैकस्य कीर्तितः ॥ —*32*
अन्यस्याप्येवमेव स्याच्छेषाः प्रागुक्त कल्पनाः ।
एतत्सर्वं समासेन तन्त्रान्तरमुदाहृतम् ॥ —*MBh. VII. 31 (ii)–33*

2. शीघ्रमन्दोच्चचापार्धसंस्कृतात् स्वीयमन्दतः ।
स्फुटमध्यग्रहाः स वै विशेषः परिकीर्तितः ॥ —*MBh. VII. 34*

3. वेदाश्विरामगुणितान्य युताहतानि ।
चन्द्रस्य शून्यरहितान्यथ मण्डलानि ॥
स्वैर्हृतानि भगणैः क्रमशो ग्रहाणां ।
कक्ष्या भवन्ति खलु योजमानदृष्ट्या ॥ —*MBh. VII. 35*

civil days in a *Mahāyuga* according to Brahmagupta as referred to in the *Khaṇḍakhādyaka.*

Again, the same stanza tells us to subtract 20 and 4 respectively from the revolutions of Mercury and Jupiter, and we arrive at the figures 17,937,000 and 364, 220, which are the revolutions of Mercury and Jupiter in a *Mahāyuga* according to Brahmagupta as given in the *Khaṇḍakhādyaka.*

Again we can compare the figures for the diameters of the Earth, the Sun and the Moon given in the *Mahābhāskarīya*, in the present day *Sūrya-siddhānta* and the *Āryabhaṭīya.*

Diameter of	*Mahābhāskarīya*	Modern *Sūrya-siddhānta*	*Āryabhaṭīya*
Earth	1,600 yojanas	1,600 yojanas	1,050, yojanas
Sun	6,480	6,500	4,410
Moon	480	480	315

Then in stanza 24, we are given the distances of the Sun and the Moon as 689, 358 and 51, 566 yojanas respectively. The same figures are worked out by Lalla according to the *Āryabhaṭīya* and quoted in the *Śiṣyadhīvṛddhida* (IV.3.4) and they come to be 459,585 and 34,377.

The stanza 25 states the longitudes of the aphelia of planets these figures tally with the corresponding figures given by Brahmagupta in the *Khaṇḍakhādyaka* :

> Longitude of aphelion of Jupiter 160°, of Venus 80°, of Saturn 240°, of Mars 110° and of Mercury 220°.

Similarly the stanza 26 gives the peripheries of planets' epicycle of apsis, which also is in concordance with the values given by Brahmagupta :

> Periphery of epicycle of apsis of Jupiter 32°, of Venus 14°, of Saturn 60°, of Mars 70° and of Merury 28°.

In the stanza 27 of the *Mahābhāskarīya*, we have the dimensions of the epicycles of conjunction for planets; these figures are also the same as given by Brahmagupta :

> Epicycles of con;uction for Jupiter 72°, for Venus 260°, for Saturn 40°, for Mars 234° and for Mercury 132°.

In the stanza 28, we have the Sun's epicycle having a periphery of 14° and the Moon's epicycle 31° ; the longitudes of

the nodes of the planets to be the same as in the *Āryabhaṭīya.* All these are the same as given by Brahmagupta in the *Khaṇḍa-khādyaka.*

In the stanza 33 we have rules for finding the geocentric longitudes of planets which may be taken to be the same as in the *Khaṇḍakhādyaka*[1]; compare these values with those in the *Sūryasiddhānta* of Varāhamihira in the Pañcasiddhāntikā, XVII. 6, but slight different from the *Āryabhaṭīya.*[2]

The last stanza of the *Mahābhāskarīya* (35) gives the dimensions in *yojanas* of the orbits of planets ; these are the same as in the modern *Sūryasiddhānta.*

Thus we find a great semblance in the constants as given by the *Mahābhāskarīya* of Bhāskara I, of the Sūryasiddhānta as given by the *Pañcasiddhāntikā* and understood by Varāhamihira, and also the constants as given by Brahmagupta in his treatises, specially the *Khaṇḍakhādyaka.* It must not be forgotten that the same Āryabhaṭa I who is the celeberated author of the *Āryabhaṭīya* is also the author of another treatise very often referred to as the *Tantra.*

I shall quote Prabodha Chandra Sengupta in connection with these similarities, and the great influence of Āryabhaṭa on Indian Astronomy. He writes in his Introduction to the *Khaṇḍakhādyaka* as follows :

> We have shown that there is much resemblance in the constants between the *Sūryasiddhānta* of Varāha and the *Khaṇḍakhādyaka* and for the matter of that with the *Tantrāntara* of Āryabhaṭa I. In my papers "Āryabhaṭa and Āryabhaṭa's Lost Work", I have established the fact that the *Sūryasiddhānta* as it existed before the time of Varāha, was made more accurate by him by borrowing the constants from Āryabhaṭa's *ardharātrika* system. That there was a *Sūryaśiddhānta*

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१. शीघ्रफलार्द्धं मध्ये मन्दफलार्द्धं च मन्दशीघ्रफले ।
सकले मध्ये स्पष्टः शीघ्रं मध्योनकं केन्द्रम् ॥ —*KK. II. 18*

२. मन्दोच्चाच्छीघ्रोच्चादर्धमृणधनं ग्रहेषु मन्देषु ।
मन्दोच्चात्स्फुट मध्याश्शीघ्रोच्चाच्च स्फुटा ज्ञेयाः ॥
शीघ्रोच्चादर्धोनं कर्तव्यमृणं धनं स्वमन्दोच्चे ।
स्फुटमध्यौ तु भृगुबुधौ सिद्धान्मन्दात्स्फुटौ भवतः ॥ —*Arya. III. 23–24*

before the time of Varāha, is seen from Section 6 of the Table on page xii given before. This point is made clear from another consideration, viz., the star table in the modern *Sūryasiddhānta*, which unmistakably points to the conclusion that the longitudes of some stars, e.g., Spica *etc.*, correspond to a time much anterior to that of Āryabhaṭa I. The great fame of Āryabhaṭa I induced Varāha, the first maker of a *neo-Sūryasiddhānta* to use the elements of Āryabhaṭa's *ardharātrika* system to supplant the older materials in it. No wonder, therefore, that there is an opinion in favour of the hypothesis that Āryabhaṭa I was the author of the *Sūryasiddhānta*. If there were a shadow of truth in it, Varāha would have admitted it. Alberuni indeed says that the *Sūryasiddhānta* was composed by *Lāṭa* (Alberuni's India, translated by Sachau, Vol. I.p. 153). We now know that this Lāṭa or Lāṭadeva was one of the first pupils of Āryabhaṭa I. He was the expounder of the Romaka and Paulīśa *Siddhāntas* as we learn from Varāhamihira's *Pañcasiddhāntikā*, (I.3). As Alberuni's statement is not corroborated by Varāha, we are not inclined to take it as correct. None of the earlier writers suggest that the *Sūryasiddhānta* was in any way modified or changed by Āryabhaṭa I.

It has now been established beyond doubt that the same Āryabhaṭa was the author of the *Aryabhaṭīya* and another *Tantra* which is now lost. There is reason in support of hypothesis that this *Tantra* itself was the first work of Āryabhaṭa I and that the *Aryabhaṭīya* was the second work from the order in which Varāha mentions them in the Stanza quoted earlier. If this hypothesis be true, the stanza in the *Aryabhaṭīya*[1], which was translated by me as :

"Now when sixty times sixty years and three quarter *yugas* also have elapsed, twenty increased by three years have elapsed since my birth."

1. षष्ट्यब्दानां षष्टिर्यदा व्यतीतास्त्रयश्च युगपादाः ।
त्र्यधिका विंशतिरब्दास्तदेह मम जन्मनोऽतीताः ॥ —*Arya. III. 10.*

should now be translated thus :

"In this *Mahāyuga* when sixty times sixty years and three quarter yugas also had passed, twenty increased by three years had elapsed since my birth."

Now Bhāskara I the author of the *Mahābhāskarīya* and the *Lagubhāskarīya*, wrote a commentary on the *Āryabhaṭīya*. The author commenting on this stanza observes that :

> "Or this was addressed by Āryabhaṭa when expounding the science to Pāṇḍuraṅgasvāmin, Lāṭadeva Niḥśanku and other pupils."[1]

This direct pupil of Āryabhaṭa I also says that this stanza does not show that the *Āryabhaṭīya* was composed when Āryabhata I was only 23 years old, but refers to the time when he probably began his career as a teacher of Astronomy.

Senagupta out of his discussion concludes that we are not justified in accepting that the Āryabhaṭīya was composed when Āryabhaṭa was only 23 years of age. This treatise as it exists in the present form must have been the composition of a mature age; it is a treatise highly finished in form; the date mentioned in this great work refers to a date when its author became a reputed *guru* or teacher.

Alberuni and Brahmagupta

Dr. E.C. Sachau in his translation of Alberuni's India (vol. II. p. 304) speaks of Brahmagupta in the following words :

> Brahmagupta holds a remarkable place in the history of Eastern civilization. It was he who taught the Arabs astronomy before they became acquainted with Ptolemy; for the famous *Sindhind* of Arabian literature, frequently mentioned but not yet brought to light, is a translation of his *Brāhmasiddhānta*; and the only other book on Indian astronomy, called Atarkand, which they knew, was a translation of his *Khaṇḍakhādyaka.*

Brahmagupta, the celebrated author of the *Brāhmasphuṭasiddhānta*, has another great work as we have said before to his credit which goes by the name *Khaṇḍakhādyaka*. This has

1. एतदेवाचार्यार्यभटस्य शास्त्रव्याख्यान समये वा पाण्डुरङ्गस्वामिलाटदेवनिःशङ्कुप्रभृतिभ्यः प्रोवाच ।

already been said that perhaps to meet the popular demand, Brahmagupta in this treatise took upon himself the task of simplifying Āryabhaṭa's *ardharātrika* system or the system of midnight day reckoning. Alberuni, the author of the *Indika* has made several references or quotations from the *Khaṇḍakhādyaka* proper and also its supplement, known as *Uttara-Khaṇḍakhādyaka*.

(a) There is a reference to the accepted circumference of the Earth, as given in the *Khaṇḍakhādyaka* (Sachau's *Alberuni*, Vol. I,p. 312)

Multiply the difference in longitude (from Ujjayinī) by the (mean) daily motion of a planet (in minutes) and divide by 4,800; apply the quotient taken as minutes negatively in places east of the meridian line of Ujjayinī and positively in places lying west.[1]

(b) The rules for finding the *ahargaṇa* as given in the *Khaṇḍakhādyaka* in I. 3-5 (Sachau's Alberuni, Vol. II, 46-47), to which Dr. Schram adds a valuable annotation, the constants being taken from the later Pauliśa Tantra as known to Bhaṭṭotpala. This Pauliśa astronomy is derived from Āryabhaṭa I's *ardharātrika* system.[2]

(c) A quotation from the Uttara *Khaṇḍakhādyaka* (Sachau's Alberuni, Vol. II, pp. 84-86) which Sengupta has given in his translation, Chapter X, pp. 148-152.

(d) A quotation also probably from the *Uttara Khaṇḍakhādyaka* (Sachau's Alberuni, Vol. II. p. 87). These stanzas are found in the *Brāhmasphuṭasiddhānta*, XIV, 47-52, also quoted by Bhaṭṭotpala as occurring in the *Brahma Siddhānta* in his commentary on the Bṛhat-Samhitā, IV, 7. The manuscripts which Sengupta used did not show them as occurring in the *Uttara Khaṇḍakhādyaka*. These relate to the dimensions of the *nakṣatras* as seen, as distinguished from the same as calculated.

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1. उज्जयिनी-याम्योत्तर-रेखायाः प्रागृणं धनं पश्चात् ।
देशान्तर भुक्तिवधात् ख खाष्टवेदैः कलाद्याप्तम् ॥ —*KK. I. 15.*

2. —*KK. Pt. B.* Misra's edition, *p. 145.*

(e) Two quotations from the *Uttara Khaṇḍakhādyaka* relating to the celestial co-ordinates of Canopus and Sirius (Sachau's Alberuni, Vol. II, p. 91). Present manuscripts do not show these stanzas, which are probably the same as stanzas 35-36 and 40 of Chapter X of the *Brāhmasphuṭasiddhānta.*

(f) Two quotations from the *Khaṇḍakhādyaka* proper as alleged by Alberuni (Sachau's Alberuni, Vol.II, p. 116). According to Āmarāja, the first is a couple of stanzas of which the author is Bhaṭṭotpala and not Brahmagupta. The second quotation cannot be traced. These relate to finding the possibility of an eclipse whether of the Sun or of the Moon.

(g) Two quotations from the *Khaṇḍakhādyaka* proper as asserted by Alberuni (Sachau's Alberuni, Vol. II. p. 119). These relate to finding the Lords of the year and of the month. According to Āmarāja the rules in question were given by Bhaṭṭotpala and not by Brahmagupta. Pṛthūdaka in his commentary on the first chapter at its concluding portion says ;

> "In this work the *Khaṇḍakhādyaka*, the teacher (Brahmagupta) has not given the rules for finding the Lords of the year and the month[1]."

1. अथाऽत्र खण्डखाद्यके वर्षाधिपमासाधिपा नयनमाचार्येण नाभिहितम् ।

—: o :—

Reference

P.C. Sengupta : *The Khaṇḍakhādyaka, 1934.*
K.S. Shukla : *Mahābhāskarīya, 1960.*
K.S. Shukla : *Sūrya-Siddhānta, 1957.*

Chapter IV

Brahmagupta's Originality in the Khaṇḍakhādyaka

Sengupta in his Indroduction to the Commentary of the *Khaṇḍakhādyaka* has discussed this point. We shall reprodūce here some of the points mentioned by him.

Brahmagupta's Khaṇḍakhādyaka

(i) Brahmagupta does not accept the system of Āryabhaṭa but has simplified it in the *Khaṇḍakhādyaka* proper ; and here he has given the system which he thinks to be correct.

Uttar Khaṇḍa Khādyaka

(ii) In the *Uttara-Khaṇḍakhādyaka*, he has further corrected some of his results, given earlier in the *Khaṇḍakhādyaka* proper. In the proper *Khaṇḍakhādyaka*, Brahmagupta assignes to the longitude of the Sun's apogee the value 80°, whereas in the *Uttara* text he corrects it to 77° (UKK. 4) :

> As the process of finding the apparent places of planets as given by Āryabhaṭa does not make them agree with observation, I shall, therefore, speak of this process. Of the Sun the apogee is at two signs and seventeen degrees (2 signs 17°=60 plus 17 degrees=77°).[1]

Compare this with the value given in the *Khaṇḍakhādyaka* proper (I.13)[2] :

The longitude of the Sun's apogee is 80° [KK.I,13] (The Sun's apogee is 80° or two signs plus 20 degrees) *inocco* means

1. न स्फुटमार्य्यभटोक्तं स्पष्टाकरणं यतस्ततो वक्ष्ये ।
भानुमती मन्दोच्चं राशिद्वयमंशकाश्च सप्तदश ॥ *UKK. IX 4*

2. भागाशीतिरिनोच्चं शशिनः पादोनकृत शरकृतोनाद् ।
भगणादि द्वित्रिरदैर्वसुनव यम नव गुणैः सकलम् ॥ *KK. I, 13*

mandocca of the Sun). The value given in the *Pañcasiddhāntikā*, IX.7-8) is also the same.

Let us compare it with the present value. According to the astronomical constants as given in the *Conn. des Temps.*, the longitude of the Sun's apogee in 499 A.D. (i.e. 1,400 years before 1900 A.D.) was

—77° 19′19.44″ according to *Conn.des Temps'* equation.

—76° 40′37.22″ according to Newcomb's equation.

The mean of these two values is very nearly 77° as given by Brahmagupta in the *Uttara* text. Thus the value given by Brahmagupta is more correct than the value given by Āryabhaṭa. The *Āryabhaṭīya* gives the value 78° which is less correct.

Brahmagupta more correct than Āryabhaṭa

(iii) Brahmagupta detected that Āryabhaṭa had made the Moon's apogee quicker and nodes slower, than they really are. In both the cases, Brahmagupta made rather an over-correction. We shall give the extract from *Uttara-Khaṇḍakhādyaka* in this connection :

> Multiply the *ahargaṇa* by 110, increase the product by 511 and divide by 30, 31; subtract the result taken as revolutions, etc., from the mean Moon; the final result is the Moon's apogee.[1]

Evidently Brahmagupta assumes that the anomalistic month=3031/110 days. This convergent to the anomalistic month was known to the author of the *Vasiṣṭha Siddhānta* as summarised in the *Pañcasiddhāntikā*[2] (II-2-6).

According to Brahmagupta, the length of the anomalistic month

$$= \frac{1582236450000 - 4320000000}{57753300000 - 488105858} \text{ days.}$$ (*BrSpSi*. I.15,16,18, and 20)

= 27.55454641 days which is for 1900 A. D.

= 27.5545502 days according to Radau.

= 27.554602 according to the *Āryabhaṭīya*.

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1. द्युगणात् ख रुद्र गुणिताद् भवशरयुक्ताच्छशिन्निखाग्नि हृतात् ।
भगणादि फलं शोध्यं मध्यचन्द्राच्छशाङ्कोच्चम् ॥ (*UKK*. IX. 5)

Here also Brahmagupta is more accurate.

Again, the length of the sidereal period of the Moon's apogee

$$= \frac{1577918450000}{488105858} \text{ days}$$

$$= 3232.732048 \text{ days.}$$

Āryabhaṭa's value of the same is 3231.987844 days, and the modern value is 3232.3754 days. Hence Brahmagupta's result is by 0.3566 of a day out, while Āryabhaṭa's is by 0.3876 of a day in.

> Further in the *Uttara-Khaṇḍakhādyaka*(IX.10) we have: Deduct 354½ from the *ahargaṇa*, divide the remainder by 6792 ; subtract the quotient that is obtained in revolutions etc. from the circle : the result is the longitude of the ascending node.[1] (IX.10)

Here Brahmagupta gives the approximate period of the sidereal revolution of the Moon's node to be=6792 days. This according to his *Brāhmasphuṭasiddhānta* $= \frac{1577916450000}{232311168}$ days

= 6792.25396 days, which according to Lockyer would be 6793.39108 days and according to the *Khaṇḍakhādyaka* proper is 6794.75083 days. Hence Brahmagupta's attempt to correction makes the node quicker than it actually is.

Brahmagupta corrects Mars's Aphelion Point

(iv) Again Brahmagupta states that the longitude of Mars's aphelion should be increased by 17^0 and that of Jupiter by 10^0. Evidently here too, Brahmagupta is more correct than Āryabhaṭa. The passage in the *Uttara Khaṇḍakhādyaka* is as follows in this connection :

> Of Mars the apogee (the aphelion point) is to be increased by 17^0, that of Jupiter by $10°$; from the *śighra* of Venus 74′ are to be subtracted ; Saturn's equation of apsis should be decreased by its one-fifth ; the *śighra* equation of Mercury should be increased by

1. सार्द्ध कृतेषु गुणोनादहर्गणाद् द्विनवमुनि-रसैर्भक्तात् ।
यन्मण्डलादि लब्धं चक्रात् संशोध्य तत् पातः ॥ —*UKK. IX 10*

one-sixteenth.[1]

This stanza says that in 499 A.D., Mars's aphelion point had a longitude of 127° ; of Jupiter the longitude of the aphelion was 170°. (*KK.II.* 6[2])

According to Newcomb's rule, the longitude of the aphelion point of Mars in 499 A. D. works out to have been = 128°28'12''. According to the *Conn. des. Temps*' rule, the same was 128°27'51''. Hence Brahmagupta's determination of Mars's aphelion is correct within 1°30' and is therefore, quite satisfactory. According to the *Khaṇḍakhādyaka* proper it was 110°, and according to the Āryabhaṭīya 118°.

Of planets, beginning with Mars, the degrees of longitude of the apogees are respectively 11, 22, 16, 8 and 24, each multiplied by 10. (*KK .II. 6*)

Thus the longitudes of apogees of Mars = 110 (3 signs 20°); of Mercury = 220° (7 signs 10°) ; of Jupiter = 160° (5 signs 10°); of Venus = 80° (2 signs 20°) and of Saturn = 240° (8 signs). Compare these values with those given in the *Pañcasiddhāntikā* XVII. 2 (the *Sūrya-siddhānta)*.

Again according to this stanza Jupiter's aphelion had a longitude of 170° in 499 A.D.

According to *Conn. des. Temps*' rule the same was 170°25'. Thus here too, Brahmagupta is very accurate. According to the *Khaṇḍakhādyaka* proper, Jupiter's aphelion had a longitude of 160° (*KK*. II.6) and according to the *Āryabhaṭīya*, the value was 180°.

Brahmagupta First to Use Second Differences

All these illustrations reproduced here very well establish the point that the great Indian astronomers from Āryabhaṭa I to Brahmagupta were aware of the methods of separating the two distinct planetary inequalities, viz., that of the apsis and of conjunction in the cases of the five 'star' planets (*PSi.* Introduction Lii). In the *Khaṇḍakhādyaka*, Brahmagupta having given the "sines" and the equations of the Sun and the Moon

1. सप्तदशांशैरधिकं भौमस्योच्चं गुरोर्द्वाशाभिरंशैः ।
सितशीघ्रात् कृतमुनयो लिप्ताः शोध्याः शनेः फलं मान्द्यम् ॥
पञ्चांशोनं शैघ्र्यं षोडशभागाधिकं बुधस्य फलम् ॥ —*UKK*. IX. 11

2. मन्दांशा दशगुणिता रुद्रा द्वियमाश्च षोडशाष्टजिनाः । —*KK. II*. 6

at the interval of 15° of arc of the mean anomaly, in the *Uttara Khaṇḍakhādyaka* teaches, for the first time in the history of mathematics, the improved rules for interpolation by using the *second difference.* This very important feature I am reproducing here from the translation by Senagupta of the verse [1] (*UKK*. *8*) :

> Multiply the residual arc left after division by 900′ (i.e by 15°), by half the difference of the tabular difference passed over and that to be passed over and divide by 900′ (i. e. 15°) : by the result increase or decrease, as the case may be, half the sum of the same two tabular differences ; the result which, whether less or greater than the tabular difference to be passed, is the true tabular difference to be passed over. (*UKK*. *8*)

The rule given here applies to the case of all functions hitherto considered in the *Khaṇḍakhādyaka,* which are tabulated at the difference of 15° of arc of the argument. They are :

(i) the tabular differences of the Sun's equation,

(ii) the tabular differences of the Moon's equation.

(iii) the tabular differences of the 'sines'.

Sengupta has illustrated the rule by an example belonging to the table of sines.

Illustration—To find the 'sine' of 57°.

Brahmagupta's table of sines in the *Khaṇḍakhādyaka* is as follows :

> Thirty increased severally by nine, six and one; twenty-four, fifteen and five, are the tabular differences of sines at intervals of half-a-sign. For any arc, the 'sine' is the sum of the parts passed over, increased by the proportional part of the tabular difference to be passed over.[2] (*KK*.I.30 ; also III.6)

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1. गतभोग्य खण्डकान्तरदलविकलवधात् शतैर्नवभिराप्त्या ।
तद्युतिदलं युतोनं भोग्यादूनाधिकं भोग्यम् ॥ —*UKK*. *IX*. *8*

2. त्रिंशत् सनवरसेन्दुजिन (तिथि) विषयागृहार्द्ध चापानां ।
अर्द्धज्या खण्डानि ज्या भुक्तैक्यं सभोग्यफलम् ॥ —*KK*. *I*. *30; also III*. *6*

This can be shown in the tabular form thus :

Arc	'Sine'	Tabular diference	Second difference
0°	0		
15°	39	39	
30°	75	36	—3
45°	106	31	—5
60°	130	24	—7
75°	145	15	—9
90°	150	5	—10

Now 57° = 3420 minutes=900′×3+720′. Thus three of the tabular differences are considered as passed over ; the last one being 31 and the one to be passed over is 24.

The true tabular difference by the rule, for arc 57°,

$$=\frac{31+24}{2}-\frac{720}{900}\times\frac{31-24}{2}$$

Hence the 'sine' of 57°

$$=39+36+31+\frac{720}{900}\left\{\frac{31+24}{2}-\frac{720}{900}\times\frac{31-24}{2}\right\}$$

$$=125.76$$

As worked out from the logarithm tables the same comes out to be 125.80.

Again 'sine' of 57° from Brahmagupta's formula

$$=106+\frac{720}{900}\times 24+\frac{31-24}{2}\times\frac{720}{900}-\left[\frac{720}{900}\right]\times\frac{31-24}{2}$$

$$=106+\frac{720}{900}\times 24+\frac{720}{900}\left[\frac{720}{900}-1\right]\times\frac{24-31}{2}$$

This in fact is the modern form the interpolation equation up to the term containing the second difference. Brahmagupta thus takes a decidedly improved step here and is undoubtedly the *first man in the history of mathematics* who has done this. One should also remember that in the case where the function is not tabulated at a constant interval, Brahmagupta's rule is remarkable.

Brahmagupta First to Introduce Sine Rule in Indian Plane Trigonometry

In this connection, we shall reproduce the following verse from the *Khaṇḍakhādyaka* :

> Multiply the 'sine' of the (*Śīghra*) anomaly by the 'sine' of the maximum Śīghra equation and divide by the 'sine' of the corresponding *Śīghra* equation, the result is the '*Śīghra* hypotenuse' when the (*Śīghra*) anomaly is half a circle, this śīghra hypotenuse is equal to the radius diminished by the 'sine' of the maximum equation ; when the anomaly is equal to the whole circle, the same is equal to the radius increased by the same 'sine' of the maximum equation.[1]

Let S, E and P be the positions of the Sun, the Earth and the planet, say Mars, respectively. Complete the parallelogram SEMP ; with M as centre and MP as radius, describe a circle. This circle is the epicycle of conjunction of Mars. Produce EM to cut this circle at K. The ∠PMK = ∠S'SP (the point S' is on ES produced), the angle gained by the Earth over Mars since the preceding conjunction. The ∠PMK is called the śīghra anomaly or anomaly of conjunction. We take EM=360, and MP=234. The ∠PEM, which is equal to ∠PES, the annual parallax of Mars, is called the *śīghra* equation. The ∠MPE is equal to the ∠SEP, the elongation. The ∠PMK is given, and PM and ME are also given. Hence in the triangle MPE, we have

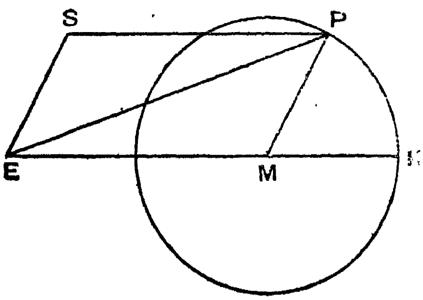


Fig. 4

$$\tan \tfrac{1}{2}(P-E) = \frac{EM-MP}{EM+MP} \tan \tfrac{1}{2} PMK$$

$$= \frac{126}{594} \tan \tfrac{1}{2} PMK$$

$$\therefore L \tan \tfrac{1}{2}(P-E) = \log \left\{ \frac{126}{594} \right\} + L \tan \tfrac{1}{2} PMK$$

We have also $\frac{1}{2}(P+E) = \frac{1}{2}\angle PMK$

1. केन्द्रज्याऽन्त्यफलज्या गुणिता फलजीवया हृताकर्णः ।
त्रिज्यान्त्य फलज्योना चक्रार्द्धे संयुता चक्रे ॥ *KK. VI. 1.*

$$\text{Now } \log \left\{ \frac{126}{594} \right\} = 1.3265841.$$

The values of the ∠PMK and the ∠PEM and Brahmagupta's values as given in the verse[1] are presented below in a tabular form :

∠PMK=	28°	60°	90°	121°	135°	148°	164°	173°
∠PEM=	10°58′	23°1′	33°1′	39°56′	40°23′	37°31′	25°32′	12°35
Brahmagupta's ∠PEM=	11°	23°	33°	40°	40°30′	37°30′	25°30′	12°30′

It will be seen that Brahmagupta gives the values of the equation within 1/8th of a degree. It seems inexplicable why such discrepancies should remain in Brahmagupta's calculations. It is probable that he wanted to state his equations to the nearest half a degree.

Now we shall take up the Sīghra equations of Mars, and then revert to the Sine Rule. We have in the *Khaṇḍakhādyaka :*

Mars, by the degrees of *Śīghra* anomaly (i.e. anomaly of conjunction) of 28 getting at the corresponding equation of 11° rises (heliacally) in the east ; by the next 32° gets 12° more of the equation ; by the next 30°, 10° more ; by the next 31°,7°, more ; by next 14°, half a degree ; these are positive ; by the next 13°, negative 3° ; by the next 16° ; negative 12° after this he is retrograde ; by the next 9°, negative 13° ; by the next 7°, negative 12½°. After this the parts of the equations occur in the reverse order[1].

On the basis of this we have the following table of the *Śīghra* equations for Mars ;

Degrees of anomaly of conjunction	Equation of conjunction	Phenomena
0°	0°	Motion direct.
28°	+11°	Rises in the east.

1. भौमोऽष्टयमै रुद्रान् भुक्त्वा पूर्व्वोदितोरदैरर्कान् ।
ख_ गैर्दशारूपगुणैः सप्तांशा मनुभिरर्द्धांशान् ॥
धनमृ मग्नि शशाङ्कैस्त्रीनष्टया भास्करानतो वक्री ।
नवभिरु योदशानगैर्द्वादशासार्द्धान् विलोमोऽतः ॥ KK.II.8-9

Degrees of anomaly of conjunction	Equation of conjunction	Phenomena
60°	11+12=+23°	
90°	23+10=+33°	
121°	33+ 7=+40°	
135°	40+ ½=+40°30'	
148°	40°30'—3°=+37° 30'	
164°	37°30'−12°=+25°30'	Retrograde motion begins.
173°	25°30'—13°=+12°30'	
180°	12°30—12°30'=0°0'	
187°	—12°30'	
196°	—25°30'	Direct motion begins.
212°	—37°30'	
225°	—40°30'	
239°	—40°	
270°	—33°	
300°	—23°	
332°	—11°	Sets in the west.
360°	0°	

Now we come back to our discussion on the verse VI.1.

The *Śighra* hypotenuse spoken of here is EP, when SP or EM is taken to be R; when ∠PEM is a maximum, PM is its 'sine'.

It would be seen from the figure that

$$EP=\frac{R \sin PMK \times PM}{R\sin PEM}$$

This may again be written as

$$\frac{EP}{\sin PMK}=\frac{PM}{\sin PEM}$$

This is equivalent to the sine rule for a triangle in plane trigonometry. Brahmagupta is here seen to be the first person to give it in Indian mathematics. This expression reminds us of the famous relationship in respect to triangle ABC :

$$\frac{a}{\sin A}=\frac{b}{\sin B}=\frac{c}{\sin C}$$

Brahmagupta corrects
Dimensions of the Epicycle of Apsis

Brahmagupta corrects the dimensions of the epicycles of apsis of the Sun and Moon by—1/42 nd part and 1/48th parts respectively, The reference may be made to the following verse in the *Uttara Khaṇḍakhādyaka* :

> The Sun's equations are to be made less by *dvikṛtāṁśonam* (1/42nd) and the Moon's equations, increased by *vasuvedabhāgayutam* (1/48th). Multiply the Sun's equation a planet's daily motion in minutes and divide by the number of minutes of a whole circle and this is called *Bhujāntara* correction and applied in the same way to the planet as the equation is applied to the Sun.[1]

The Sun's epicycle of apsis has the dimension 14° in the *Khaṇḍakhādyaka* proper. With the correction introduced here, the value becomes $14^\circ \left[1-\frac{1}{42}\right] = 13^\circ\ 40'$.

The correction to the Moon's equations would make the epicycle's dimension changed from 31° to $31^\circ \left[1+\frac{1}{48}\right] = 31^\circ 38' 45''$.

Pṛthūdaka's commentary further corrects it to $31^\circ(1+\frac{1}{52}) = 31^\circ 35'$

Brahmagupta 's correction to Saturn's epicycle of apsis is—1/5th part and that to the *Śīghra* epicycle of Mercury 1/16th part as seen in the verse :

> Of Mars the apogee (the aphelion point) is to be increased by 17°, that of Jupiter by 10° ; from the *Śīghra* of Venus 74' are to be subtracted ; Saturn's equation of apsis should be decreased by its one-fifth and the *Śīghra* equation of Mercury should be increased by one-sixteenth.[2]

In the *Khaṇḍakhādyaka* proper (II.6), we have been given the longitudes of the apogee of planets : Mars 11°, Mercury 22°, Jupiter 160°, Venus 80° and Saturn 240°. Now with these corrections introduced in the *Uttara Khaṇḍakhādyaka* in the above

1. द्विकृतांशोनं रविफलमिन्दोर्वसुवेदभागयुतम् ।
   अर्कफलभुक्तिघाताद् भगणकलाप्तं भुजान्तरं रविवत् ॥ *UKK. IX. 9*
2. सप्तदशांशैरधिकं भौमस्योच्चं गुरोर्दशभिरंशैः ।
   सितशीघ्रात् कृतमुनयो लिप्ताः शोध्याः शनेः फलं मान्द्यम् ।
   पञ्चांशोनं शैघ्र्यं षोडशभागाधिकं बुधस्य फलम् ॥ *UKK.IX.11*

verse, the aphelion point of Mars in 499 A.D. had a longitude of 110 plus 17=127°; of Jupiter 160 plus 10=170°.

According to Newcomb's rule, the longitude of the aphelion point of Mars in 499 A.D. works out to have been 128°28'12''. The same according to *Conn. des Temps* rule would be 128°27'51''. Hence Brahmgupta's determination of Mars's aphelion is correct within 1°30', and may be, therefore, regarded as very satisfactory. According to the *Khaṇḍakhādyaka* proper this value was, as already said, 110°, while according to the *Āryabhaṭīya*, it was 118°.

The same may be said regarding Jupiter's aphelion. According to the *Khaṇḍakhādyaka* proper the value of its longitude is 160°, according to the *Āryabhaṭiya* it was 180°; according to *Conn. des. Temps*' rule, it would be in 499A. D, 170°25', and the value given by Brahmagupta in the *Uttara Khaṇḍakhādyaka*, it is 170°.

We have thus shown by many illustrations the important corrections introduced by Brahmagupta in his *Khaṇḍakhādyaka* specially the *Uttara* part. Brahmagupta was highly original in his methods of calculations, accuracies and interpolations. He introduced new ideas in mathematics. He went much ahead Āryabhaṭa in many details. He so many times did not follow Āryabhaṭa in calculations. In the *Khaṇḍakhādyaka* proper, his treatment of parallax in the calculation of solar eclipses is different from that of Āryabhaṭa. The methods followed here are the same as propounded by him in the *Brāhmasphuṭasiddhānta*.[1]

Senagupta is right when he says : As has already been remarked, these corrections and innovations in the *Uttara Khaṇḍakhādyaka* paved the way for the acceptance of his great work the *Brāhmasphuṭasiddhānta* as a standard work on astronomy by the western Indian school of astronomers. The directness of the treatment of topics, and the simplicity of calculations taught in the *Khaṇḍakhādyaka* made it very neat handbook for the beginner. These two works of Brahmagupta were perhaps the only astronomical works in circulations in western India when the Arabs conquered Sind early in the eighth century

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1. *On Parallax*—

नाडी चतुष्कविधिना सर्वत्र समो यतस्ततः स्थूलः ।
मानार्थं कर्म महत् कृतमार्यभटेन लघुनि सति ॥ *BrSpSi*. XI. 33

(712 A.D.) and the new conquerers learnt Indian astronomy and mathematics from these works as has been observed by Sachau. Alberuni who came to India early in the 11th centuty of the Christian era, learnt Indian astronomy chiefly by studying the *Khaṇḍakhādyaka* and the *Bṛhat-Saṁhitā* of Varāhamihira, and both of them with the help of commentary of Bhaṭṭotpala.

—:c:—

Reference

P.C. Sengupta : *The Khaṇḍakhādyaka*, *1934.*

CHAPTER VI

Indian Luni–Solar Astronomy

In this chapter, it is proposed to give an account of astronomical constants and the equations in Indian luni-solar astronomy and to present a comparative view of these quantities with the corresponding ones in Greek and modern Astronomy. This account has been reproduced from P. C. Sengupta's. Appendix I of the *Khaṇḍakhādyaka* It has been shown that in many cases the Indian values of these constants are more accurate than the Greek values. and in Indian lunar astronomy the equations or inequalities discovered are the most startling.

Solar Astronomy

In solar astronomy the length of the year was determined by Āryabhaṭa[1] from the heliacal risings of some bright star at the intervals of 365 and 366 days.

(1) The year according to the Āryabhaṭīya

$= \frac{1577917500}{4320000}$ days=365.2586805 days,

=365 da. 6 hrs. 12 mins. 29.64 secs.

(2) The same

$= \frac{1577917800}{4320000}$ days=365.25875 days.

=365 da. 6 hrs. 12 mins. 36 secs., according to the *Khaṇḍakhādyaka*, the *Sūryasiddhānta* of Varāha and the modern *Sūryasiddhānta*.

(3) It is

$= \frac{1577916450}{4320000}$ days=365.2584375 days,

=365 da. 6 hrs. 12 mins. 9 secs., according to the

1, P. C. Sengupta, "Āryabhata's Method of determining the Mean Motions of Planets," *Bulletin of the Calcutta Mathematical Society*. Vol. XII, No. 3.

Brāhmasphuṭa Siddhānta of Brahmagupta.

Now the mean sidereal year

=365 da. 6 hrs. 9 mins. 9.3 secs. (Lockyer).

The mean anomalistic year

=365 da. 6 hrs. 13 mins. 49.3 secs. (Lockyer).

The mean tropical year

=365 da. 5 hrs. 48 mins. 46.054 secs. (Lockyer).

Though we take that Indian year was designed to be the sidereal year, it approached most closely the anomalistic year ; and its excess over the sidereal year was about 3 minutes. From this consideration it appears that the Indian astronomers were justified in taking the Sun's apogee to be fixed.

Against the error of+3 min. in the Indian sidereal year, we may point out that—

(1) The Hipparchus-Ptolemy tropical year

=365 da. 14' 48" in sexagesimal units.[1]

=365 da. 5 hrs. 55 min. 12 secs., which has an error of about+6 min.

(2) Meton's sidereal year

$= \left[365+\frac{1}{4}+\frac{1}{76}\right]$ days[2]

=365 da. 6 hrs. 18 min. 57 secs. which has an error of +9 min. 48 secs. nearly.

(3) The Babylonian sidereal-year was 4½ min. too long.[3]

Thus the Indian value of it is closer to the true value.

Again in 150 A.D. the longitude of the Sun's apogee according to the *Conn. des Temps* was

$$=101^\circ\, 13'\, 15''.17 - 6189''.03 \left[\frac{1900-150}{100}\right]$$

$$=1''.63 \times \left[\frac{1900-150}{100}\right]^2$$

$=71^\circ\, 16'\, 26''.37$

while Ptolemy states it to be 65° 30′ which was wrong by—5° 36′ 27″ :

1. *Syntaxis*, Karl Manitius's edition, Vol. I. p. 146.

2. Ibid, p. 145.

3. *Encyclopaedia Britannica*, History of Astronomy.

4. *Syntaxis*, Vol. I. p. 148. The Romaka Siddhānta of the *Pañca-siddhāntikā*, VIII. 2, indicates the Sun's apogee to be at longitude of 75° ; this was perhaps a correction made by Lāṭadeva to the Greek constant.

In 500 A. D (Āryabhaṭa's time) the longitude of the Sun's apogee by the same rule works out to be=77°19′19.44″.

Āryabhaṭa states this to be 78° in the Āryabhaṭīya, Brahmagupta in the Uttarādhyāya of the *Khaṇḍakhādyaka* states the same to be 77°, while the Khaṇḍakhādyaka gives it as=80°. Hence the Indian findings of the longitude of the Sun's apogee were more accurate.

Again as to the Sun's equations of the centre we find that the *Āryabhaṭīya* states the periphery of the Sun's epicycle to be 13°30′, The *Khaṇḍakhādyaka* gives it as 14° ; while according to the Indian form, Ptolemy's value of the same is 15°. Hence according to these writers, the Sun's equations at 90° of the mean anomaly are :—

According to the *Āryabhaṭīya*	=2° 8′ 54″.
,, ,, *Khaṇḍakhādyaka*	=2° 1′ 40″.
,, ,, Brahmagupta	=2° 7′ 20″.
,, ,, Ptolemy	=2° 23′ 3″.
The modern value	=1° 55′ 97″.

Thus the Indian equations of the Sun are in general by more correct than the Greek ones. The Indian constants in solar astronomy are thus, generally, more accurate than the Greek ones. We now turn to the Indian Lunar astronomy.

Lunar Astronomy

Before discussing the constants in Indian lunar astronomy it is necessary to state something as to the time when the Moon was observed by our ancient astronomers and the astronomers from Āryabhaṭa I (499 A.D. to Pṛthūdaka Svāmī (864 A.D.). The months were reckoned from the first visibility of the crescent at the time of the *Mahābhārata* (1400 B. C.). We have a passage in the Bhīṣmaparva where Vyāsa speaks of the evil omens on the eve of the Kurukṣetra war thus—

चन्द्रसूर्य्यावुभौ ग्रस्तावेकामासीं त्रयोदशीम् ।

"That the Moon and the Sun have been both eclipsed on the 13th days of the light and dark halves of the same month."

The eclipses could not take place on the 13th days of the month unless the months were reckoned from the first visibility of the crescent. This was the custom in Babylonia and it has still survived in the Mahomedan world. Even in the *Pañca siddhāntikā* of Varāhamihira (540 A. D.), there is a special

chapter on शशि-दर्शनम् or the fiirst visibility of the crescent. It is thus clear that the practice was to observe the Moon when very near the Sun.

Again Āryabhaṭa says that 'रवीन्दुयोगात् प्रसाधितश्चेन्दुः', "the Moon was determined from her conjunctions with the Sun." The Moon was observed by him at the time of solar eclipses, or at the time of the first visibility of the crescent.

Even up to the time of Pṛthūdaka, the accuracy in lunar astronomy was chiefly aimed at the time of eclipses. Thus in his commentary on the *Khaṇḍakhādyaka* IV, he makes the following introductory remarks :—

"All knowledge relating to (luni-solar) astronomy is desired by the wise (or cultured) specially for knowing the right instants of opposition or conjunction ; these instants are, however, not visible to the eye. Of other things such as *tithis*, *nakṣatras* and *Karaṇas*, as the planets, the Sun and the Moon, are not clearly observed, their beginnings and ends are not visible. Men see the agreement between calculation and observation at the times of solar and lunar eclipses. Hence the word of the astronomers is esteemed amongst men even in respect to such things as *tithis*, etc."[1]

Thus the chief aim of the ancient Indian astronomers was to calculate the eclipses accurately and the Moon was observed chiefly at lunar or solar eclipses, though the time for observation related also to the fiinding of the first visibility of the crescent. This latter phenomena did not perhaps lead them to directly observing the Moon's position at such times by using instruments.

Moon's Mean Motion

The practice of observing the Moon at the time of the eclipses alone led to the determination of the synodic month with the following results :—

(i) Mean synodic month according to the *Āryabhaṭīya*

$$=\frac{1577917500}{57753336-4320000}\text{ days},$$

$$=29.530582 \text{ days}.$$

1. बाहुल्येन पर्व्वज्ञानार्थं सकलं ज्ञानमिष्यते शिष्टैः । तेषां च पर्व्वाणां दर्शनं नास्ति । अन्येषामपि तिथिनक्षत्रकरणानां तस्मात् तेषां शशिभास्करयोरव्यक्तिर्यस्मात् । शशिभास्कर-ग्रहणयोर्दृग्गणितैक्यं लोकः पश्यति । तस्मात् तिथ्यादिष्वप्यर्थेषु दैवज्ञं वाक्यं लोके आद्रियते ।

(ii) The same according to the *Khaṇḍakhādyakā* =29.5305874 days.

(iii) The same according to the *Brāhma-sphuṭa-siddhānta* =29.530582 days.

(iv) The same according to Ptolemy=29 da. 31′ 50″ 8″ 20″ in sexagesimal units=29.5305927 days

The modern value according to Newcomb and Radáu =29.5305881 days.

Hence the *Khaṇḍakhādyaka* mean length appears to be the closest approximation.

The mean sidereal month must have been deduced from the mean synodic month and the year adopted. Hence no comparison need be made of this element here.

We will now consider the sidereal periods, the nodes and the apogee of the Moon. These are shown below :-

According to	Sid. Per. of Moon's Apogee	Sid. per. of the Ascending Node
Āryabhaṭīya	3231.987079 da.	6794.749511 da.
Khaṇḍakhādyaka	3231.987844 da.	6794.750834 da.
Brāhma-sphuṭa - Siddhānta	3232.73411 da.	6792.25396 da.
Ptolemy	3232.617656 da.	6796.45571 da.
Modern values (Lockyer)	3232.37543 da.	6793.39108 da.

Here also the Indian values show a closer approximation to the true values, Brahmagupta's figures representing the nearest approach.

Other Constants

So far the Indian values of the constants have been more accurate than the Greek ones ; but as to the inclination of the Moon's orbit the Greek value is more accurate than the Indian value.

Inclination of the lunar orbit

Indian value=4°30'.

Greek value=5°0'.

Modern mean value=5°8'43".427 (Brown)

This discrepancy confirms the conclusion, that the observation of the Moon was restricted to the time when she was near a node, either at solar or lunar eclipses, where a small error of observation magnified itself into about half a degree.

We now turn to the parallaxes of the Sun and the Moon :-

	Sūn's Mean Hor. Parallax	*Moon's mean Hor. Parallax*
Āryabhaṭīya	3'55".62	52'30"
Kaṇḍakhādyaka	3'56"5.	52'42".3
Ptolemy	2'51"	53'34"
Modern values	0'8".806	57'2".79

As to the Sun's horizontal parallax, the ancients were of course totally wrong, but in respect to that of the Moon their values were fairly approximate.

We next consider the angular semi-diameters of the Sun and the Moon. These are :-

	Moon's Mean Semi-diameter	*Sun's Mean Semidiameter*
Āryabhaṭīya	15'45"	16'29".4
Khaṇḍakhādyaka (Brāhma-sphuṭa-siddhānta)	16'0".22	16'15"
Ptolemy	17'40"	15'40"
Modern values	15'33".60	16'1".8

Here also the Indian values are more accurate than the Greek values.

Moon's Equations. The First Equation.

It remains now to consider the Moon's equations in ancient Indian astronomy. As has been pointed out before, obser-

vation was up to the time of Brahmagupta, restricted to the time of eclipses perhaps also of syzygies.

The modern form of the Moon's equations is

$$=377' \sin (nt-\alpha)+13' \sin 2(nt-\alpha)+\dots\dots\dots$$

$$+76' \sin [2(nt-\theta)-(nt-\alpha)]+40' \sin 2(nt-\theta)\dots\dots\dots\dots\dots$$ [1]

where nt=mean longitude of the Moon, α the longitude of the perigee, θ=longitude of the Sun.

Here the first two terms, viz., $377' \sin (nt-\alpha) + 13' \sin 2(nt-\alpha)$, are due to elliptic motion about the Earth in one focus; the term $76' \sin [2(nt-\theta)-(nt-\alpha)]$ is known as the evection. We combine a part of the first term with the evection term and the expression for the equation of centre becomes $=301' \sin (nt-\alpha)+13' \sin 2(nt-\alpha)+\dots\dots\dots\dots+152 \sin (nt-\theta) \cos (\theta-\alpha)+40' \sin 2(nt-\theta)$.

Now at syzygies and eclipses $\sin (nt-\theta)$ and $\sin 2(nt-\theta)$ will very nearly vanish. Hence according to modern astronomy at the syzygies and eclipses, the chief term of the Moon's equation$=301' \sin(nt-\alpha)$.

This according to the *Āryabhaṭīya*

$=300' 15'' \sin (nt-\alpha)$

" " *Khaṇḍakhādyaka*

$=296' \sin (nt-\alpha)$

" " *Uttara Khaṇḍakhādyaka*

$=301'.7 \sin (nt-\alpha)$

" " *Brāhmasphuṭasiddhānta*

$=293' 31'' \sin (nt-\alpha)$

" " Greek astronomy

$=300' 15'' \sin (nt-\alpha)$

very nearly.

Hence both the Greek and the ancient Indian astronomers were very near the true value of the Moon's equation at the syzygies and eclipses. Godfray in his *Lunar Theory*, page 107, observes, "the hypothesis of an excentric, whose apse has a progressive motion as conceived by Hipparchus served to calculate with considerable accuracy the circumstances of eclipses; and observations of eclipses, requiring no instruments, were then the only ones which could be made with sufficient exactness to test

1. The accurate values of the coefficients appear to be 377′ 19″.06, 12′ 57″.11, 76′ 26″ and 39′ 30″.

the truth or fallacy of the supposition." We next consider the second inequality of the Moon.

Moon's Second Inequality or Equation

In ancient times it was Prolemy who first really found a second inequality of the Moon. According to Godfray (*Lunar Theory*, p. 107) "by dint of careful comparison of observations he (Ptolemy) found that the value of this second inequality in quadrature was always proportional to that of the first in the same place, and was additive or subtractive according as the first was so; and thus, when the first inequality was at its maximum or 5°1′, the second increased it to 7° 40′ which was the case when the apse line happened to be in syzygy at the same time."

It is well known that though Ptolemy discovered the second inequality in the Moon's motion he was not able to ascertain its true nature. His corrections in this case are true when at the quadrature the Moon's apse line passes through the Sun or it is at right angles to the line joining the Earth and the Sun.[1] In the general case his construction does not lead to the elegant form of the evection term as we know it now, nor does it lead to the nice form in which it was given by later Indian astronomers from the time of Mañjula (or Muñjāla, 854 Śaka era = 932 A.D.).

As has already been pointed out, the early Indian astronomers from Āryabhaṭa to Brahmagupta aimed at accuracy in lunar calculation only for the eclipses and syzygies, and did not interest themselves about the Moon's longitude at the quadratures. Hence this second inequality is absent in the works of these makers of Indian astronomy, as also in the Pre-Ptolemaic Greek astronomy. This points to the conclusion that in both the earlier Indian and Greek systems of astronomy. the modes of observation of the Moon were copied from an earlier system of astronomy whether Babylonian or Chaldean. Even in the *Romaka Siddhānta* of the *Pañcasiddhāntikā*, there is no mention of evection.[2] Thus inspite of the transmission of a vague system of Greek astronomy, Indian astronomy as developed by Āryabhaṭa and Brahmagupta must be regarded as independent and

1. Godfray's *Lunar Theory*. pp. 108-110.

2. Vide the Summary in P.C. Sengupta's paper, "Āryabhaṭa the Father of Indian Epicyclic Astronomy." *Journal of the Department* of *letters*, vol. XVIII, Calcutta University Press.

original not only from this but also from other considerations. It sought to correct the constants as were obtained from the Babylonian and the Greek systems as has in some cases been shown already.

Mañjula's Second Equation of the Moon (932 A.D.)

We now take up in detail Mañjula's second equation of Moon. It is, however, necessary to say something about his first inequality.

This is given in the form

$$\frac{-488 \sin (nt-\alpha')}{96+\frac{488}{120} \cos (nt-\alpha')} \text{ degrees,}$$

where nt stands for the Moon's mean longitude, α''—that of the apogee.

Hence when $nt-\alpha'=90°$, the equation $= \frac{488°}{96} = 5°4' = 304'$ showing an excess of 4′ over the modern value.

It is further necessary to modify the expression for the Moon's modern form of the equation by changing α to $180°+\alpha$, as in ancient Indian astronomy anomaly is measured not from the perigee but from the apogee.

The modified form is

$$= -301' \sin (nt-\alpha) + 13 \sin 2(nt-\alpha) \ldots\ldots$$

$$-152' \sin (nt-\theta) \cos (\theta-\alpha) + 40' \sin 2(nt-\theta) + \ldots$$

Mañjula's lines giving the second equation are—

> The (mean) daily motion of the Moon diminished by 11° and multiplied by the "cosine" of the longitude of the Sun diminished by that of the Moon's apogee is the multiplier of the "sine" and the "cosine" of the longitude of the Moon diminished by that of the Sun, divided severally by 1 and 5. The results taken as minutes are to be applied negatively and positively to the Moon and to her daily motion if the quantities multiplied together are of opposite signs and in the reverse order if they are of the same sign.[1]

1. इन्दूच्चोनार्ककोटिघ्ना गत्यंशा विभवा विधोः ।
गुणो व्यर्केन्दुदोः कोट्योरूप पंचाप्तयोः क्रमात् ।।
फले शशाङ्क--तद्गत्योर्लिप्ताद्ये स्वर्णयोर्वधे ।
ऋणं चन्द्रे धनं भुक्तौ स्वर्णं साम्य वधेऽन्यथा ।। —11, 12

As to the positive or negative character of the "sine" and the "cosine" he gives the rule:—

> The mean planet diminished by its *ucca*, the apogee, aphelion or the Śighra, is called *Kendra* or mean anomaly; its "sine" from above six signs (180°) arises from half circles and are respectively positive or negative, and its "cosine" in different quadrants are respectively positive, negative, negative, and positive.[1]

The convention followed is that the "sine" is negative from 0° to 180° and positive from 180° to 360° of the arc and that the cosine is positive betwen 0° and 90°, negative between 90° and 270° and positive between 270° and 360°.

We may now symbolically express Mañjula's second inequality thus :-

$-(13^\circ\ 11'\ 35''-11^\circ)\times 8^P\ 8' \cos(\theta-\alpha)\times 8^P\ 8' \sin(D-\theta)$ where D stands for the Moon as corrected by the 1st equation; we leave out the correction to the Moon's daily motion as given in the stanzas quoted above.

The moon's new equation comes out to be

$$=-143'58'' \cos(\theta-\alpha)\sin(D-\theta).$$

This, it will be seen, is exactly the modern form of the evection as combined with a part of the equation of apsis shown before. The difference in the main is that Mañjula's constant is 144′, a quantity less by 8′. *In form the equation is most perfect, it is far superior to Ptolemy's, it is above all praise.* It is from this inequality, we trust, that Mañjula should have an abiding place in the history of astronomy. The next writer who gives the second equation is Śripati (1028 A.D.).

Śripati's Second Inequality of the Moon

The following stanzas from Śripati's *Siddhānta Śekhara,* it is said, were communicated to Sengupta by Pandit Babua Misra. Though they are probably not very correct still the general meaning is clear. They carry the following sense :

> "From the Moon's apogee subtract 90°, diminish the Sun by the remainder left; take the "sine" of the

1. ग्रहः स्वोच्चोनितः केन्द्रं षड्भादूर्ध्वं जो भुजः ।
धनर्णं पदशः कोटिर्धनर्णं धनात्मिका ॥

result; multiply it by 160′ and divide by the radius; the result is called *caraphala*. Put it down in another place, multiply it by *śara*(i.e., R vers $(D-\alpha)$ or versed sine of the Moon's distance from the apogee) and divide by the difference between the Moon's distance (hypotenuse) and the radius; the result is called *parama (cara) phala*, which is to be considered positive or negative according as the hypotenuse put down in another place is less or greater than the radius. Multiply the "sine" of the Moon which has been diminished by the apparent Sun, by the apparent *paramaphala* and divide by the radius; the final result is to be called *caraphala* to be applied to Moon negatively or positively as the Moon minus the Sun and the Sun minus the Moon's apogee (diminished by 90°) be of opposite signs; if these latter quantities be of the same signs, the new equation should be applied in the inverse order by those who want to make the calculation of the apparent Moon agree with observation.[1]

Symbolically :—

$$\frac{160' \; R \sin[\theta-(\alpha-90^\circ)]}{R} = caraphala$$

$$\mp \frac{160' \; R \sin[\theta-(\alpha-90^\circ)]}{R} \times \frac{R \text{ vers } (D-\alpha)}{H-R}$$

$= paramaphala$, according as $H >$ or $< R$

The new equation

$$= \mp \frac{R \sin (D-\theta)}{R} \times paramaphala \; .$$

1. त्रिभविरहितचन्द्रोच्चो नभास्वद् भुजज्या ।
गगननृपविनिघ्नी भत्रयज्या विभक्ता ॥
भवति चरफलाख्यं तत् पृथक् स्थं शरघ्नं ।
हृतमुडपतिकर्णत्रिज्ययोरन्तरेण ॥
परमफलमवाप्तं तद्धनर्णं पृथक्स्थे ।
तुहिनकिरणकर्णे त्रिज्यकोनाधिकेऽथ ।
स्फुटदिनकरहीनादिन्दुतो या भुजज्या ।
स्फुटपरमफलघ्नी भाजिता त्रिज्ययाप्तम् ॥
शशिनि चरफलाख्यं सूर्यहीनेन्दुगोलात् ।
तदृणमुतधनं चेन्दूच्चहीनार्कगोलम् ॥
यदि भवति हि साम्यं व्यस्तमेतद् विधेयम् ।
स्फुटगणितदृगैक्यं कर्त्तुमिच्छद्भिरत्र ॥

$$= \mp \frac{160' R \sin[\theta-(\alpha-90^\circ)]\ R \text{ vers } (D-\alpha) \times R \sin (D-\theta)}{R\ (H-R) \times R}$$

$$= \mp \frac{160' R \cos(\theta-\alpha) \times R \sin(D-\theta)}{R \times R} \times \frac{R \text{ vers } (D-\alpha)^{1}}{H-R}$$

This equation is a slightly modified one but practically the same in form as that of Mañjula, except that the constant here is 160′, greater than his by 16′. The constant is 160' also in Candraśekhara's form as we shall see later on. We next consider the Moon's inequalities as given by Bhāskara II in his *Bijopanaya,** a special work on these inequalities composed in the Saka year 1074 (=1152A.D.) two years after he had composed the *Siddhānta Śiromaṇi.*

Bhāskara II on Moon's Inequalities

His preliminary statement runs thus .—

> 112′ positive or negative representing the maximum difference. have been found by me in the daily observed Moon (as calculated and as observed) at that point of the ecliptic where the arc from the *kadamba* (i.e., its pole) passing through the zenith cuts it.[1]

Thus for observing the Moon he selected the nonagesimal as the suitable point where the uncertainty about her parallax is zero, and found ∓112′ of arc to be the maximum difference between her calculated and observed places.

Mallabhaṭṭa, perhaps a contemporary of Bhāskara II, ascribed this difference to a supposed *Sighrocca* of the Moon. Bhāskara in stanzas 9-13, refutes the existence of the Śighra in the case of the Moon, the substance of his argument begins (i) that it is against the teaching of the *Sūrya-siddhānta* and other accepted authorities, (ii) that there is no variation of the apparent angular diameter of the Moon corresponding to this alleged *Śighra,* and (iii) that planets having a *Śighra* have retrograde motion which is never the case with the Moon.

*There is some uncertainty, about this new fraction introduced by Śripati.

1. लिप्ता विधोरर्कं मह्यीमिता मे दृग्गोचराः प्रत्यहमीक्षितस्य ।
कदम्ब गोलगत-सूत्रपाते क्रान्तौ धनर्णत्वजुषो भमध्यात् ॥

—*Bijopanaya,* stanza 8

The reasons for his new equations are stated as follows:—

> When the Moon is situated at a quadrant ahead of the apogee and with the Sun at half a quadrant ahead of her, the maximum discrepancy (of 112′) is seen in the negative character.
>
> When the Moon is situated at three quadrants ahead of the apogee and with the Sun at half a quadrant behind her, the maximum discrepancy (of 112′) is seen in the positive character.
>
> When the eclipses of the Sun and the Moon take place at the apogee or the perigee of the Moon, the Moon as corrected by the equation of apsis is seen to be without any new correction called *bīja*.
>
> When the eclipses of the Sun and the Moon take place at the ends of the odd quadrants of the Moon's anomaly (measured from the apogee), the discrepancy is seen to be less by 34′.
>
> When the Moon is at the apogee, whether the Sun be ahead or behind her by half a quadrant, the discrepancy amounts to be 34′.
>
> The same discrepancy of 34′ is observed when the Moon is at the perigee and the Sun is ahead or behind her by the same distance.
>
> Thus by analysis and synthesis, and by repeated observations, this variable correction has been devised by me; let it be seriously considered by the learned.[1]

Bhāskara here speaks of six cases and we consider them one after another :—

The Moon's equations as modified to suit *siddhāntas* are given by

$$-301' \sin (nt-\alpha)+13' \sin 2(nt-\alpha)\ldots\ldots$$

$$-152' \sin (nt-\theta) \cos (\theta-\alpha)-40' \sin 2(nt-\theta)+\ldots\ldots$$

According to Bhāskara's *Siddhānta - śiromaṇi.* the Moon's equation of apsis

$$= -\frac{31^\circ\ 36'}{360^\circ} \times 3438' \sin (nt-\alpha)$$

$$= -301'\ 46''.8 \sin (nt-\alpha),$$

this agrees well with the corresponding term of the modern equation. As Bhaskara takes in all the six cases, $nt-\alpha=90^\circ$, 270°, 0° or 180°, the second term of the equation of apsis vanishes.

Case I.

$$nt-\alpha=90^\circ,\ nt-\theta=-45^\circ,\ \theta-\alpha=135^\circ;$$

Here the total equation of the Moon

$$=-301'-(76'+40')=-301'-116'.$$

This fairly agrees with Bhāskara's observation, the difference being only of 4′.

Case II.

$$nt-\alpha=270^\circ,\ nt-\theta=45^\circ,\ \theta-\alpha=225^\circ;$$

the total equation of the Moon

$$=301'+76'+40'=301'+116'.$$

This also agrees with Bhāskara's observation.

Case III.

$nt-\alpha=0^\circ$ or 180°, $nt-\theta=0^\circ$ or 180°, $\theta-\sigma=0^\circ$ or 180°, the total equation=0′, this also agrees with Bhāskara's observation.

Case IV,

$nt-\alpha=90^\circ$ or 270°, $nt-\theta=0^\circ$ or 180°, $\theta-\alpha=90^\circ$ or 270°,

---

1. तुङ्गादाद्यपदान्तस्थाद् विधोरर्के पदार्द्धतः ।
परमं चन्द्रवैषम्यं ऋणत्वेन समीक्ष्यते ॥ 20 ॥
तत् तृतीय पदान्तस्थात् पृष्ठगेऽर्के पदार्द्धतः ।
परमं चन्द्रवैषम्यं धनत्वेन समीक्ष्यते ॥ 21 ॥
चन्द्रतुङ्गे च नीचे च शशाङ्कार्कग्रहौ यदि ।
मन्दस्फुटगतश्चन्द्रो निर्वीजतुल्यमीक्ष्यते ॥ 22 ॥
ओजान्त्ययोर्विधोस्तुङ्गाच्छशाङ्कार्क ग्रहौ यदि ।
चतुस्त्रिंशत्-कलाहीनं वैषम्यं तु समीक्ष्यते ॥ 23 ॥
अग्रतः पृष्ठतो वाऽपि रवेश्चन्द्रे पदार्द्धगे ।
तुङ्गतुल्ये चतुस्त्रिंशत् कलावैषम्यमीक्ष्यते ॥ 24 ॥
एवं तन्नीचतुल्येऽपि वैषम्यं तावदेव हि ।
एवं व्यासात् समासाच्च पौनःपुन्येन वेधनात् ॥
चरवीजमिदं क्लृप्तं मया सद्भिः समीक्ष्यताम् ॥ 25 ॥

the total equation$= \mp 301'$. This does not agree with Bhāskara's statement that the total equation

$$= \mp(301' \pm 78').$$

Case V.

$$nt-\alpha=0,\ nt-\theta=\pm 45°,\ \theta-\alpha=\pm 45°,$$

the total equation

$$=0'-76'+40'=-36' \text{ or } 0'+76'-40'=+36'.$$

This fairly agrees with Bhāskara's observation.

Case VI.

$$nt-\alpha=180°,\ nt-\theta=\pm 45°,\ \theta-\alpha=180° \mp 45°$$

the total equation

$$=0'+76'+40'=0'+116', \text{ or } 0-76+40'=0'-36'.$$

This does not agree with Bhāskara's statement.

Bhāskara then states his first system of 24 equations corresponding to 24 sines in a quadrant to be 6', 13', 21', 27', 33', 39', 45', 51', 56', 61', 65', 68', 70', 72', 74', 75', 75', 76', 76' 77', 77', 78', 78', 78'.[1]

These equations, he says—"are negatively added to the equation of apsis when that is negative and positively added to the same when that is positive"[2]. In other words his new equations are complements of the equation of apsis, the two together being represented by

$$-301'\ 46''.8 \sin(nt-\alpha)-78' \sin(nt-\alpha)$$

$$\text{i.e., by} -379'\ 46''.8 \sin(nt-\alpha).$$

Hence next states his second set of equations depending on $\theta-D$, to be 6', 9', 13', 17', 22', 24', 27', 30', 32', 33', 34', 34', 34', 33', 31', 29', 26', 24', 20', 16', 11', 8', 3', 0'[3] and says :

"These minutes are negative in the odd quadrants of the argument and are positive in other quadrants.[4]"

When the value of the argument is 15°, the equation is 17',

,,	,,	,,	45°	,,	34',
,,	,,	,,	90°	,,	0',

1. *Bījopanaya*, 26-28.

2. ···फलं ऋणे ऋणं ।
धने धनं मन्दफलेन संयुतम् ।। 28 ।।

3. *Bījopanaya*, 29-32.

4. एताः कला ओजपदे ऋणं स्युर्धनं तदन्यत्र भवन्ति भूयः ।

Hence the new equation $= -34' \sin 2(\theta - D)$,
$= 34' \sin 2(D - \theta)$.

Here the symbol D stands for the Moon as corrected by the ancient Indian equation of apsis and its complement as given by Bhāskara. It is readily seen that Bhāskara is the first of all the Indian astronomers to detect the equation known as "Variation" His constant, 34', is less than the modern value by about 6', and cannot be considered as a serious error.

We now see that the sum-total of the Moon's equation as given dy Bhāskara

$$= -379' \ 46''.8 \sin(nt - \alpha) + 34' \sin 2(D - \theta),$$

the evection term being totally absent. This is a serious defect, and Bhāskara's new equations would make the Moon generally more incorrect at the syzygies and eclipses than what the ancient Indian equation of apsis would do.

Perhaps late in life when he was 69 years old in 1105 of Śaka era (=1183 A.D.) he discovered the inapplicability of his new equations at the times of eclipses and in his *Karaṇa-kutū-hala* he altogether omitted these new equations which he had given in his *Bījopanaya.*

As to Bhāskara's second inequality which is really the complement of the equation of apsis without the evection term, it is far inferior to that of Mañjula and of Śrīpati; as we have seen their form of the second inequality combines the complement of the equation of apsis and evection in the mathematically correct form. For the discovery of such a form of the equation as of these authors, very patient, careful and frequent observation must have been coupled with very careful and nice comparison of observed facts.

As to "variation" it was first discovered by Abul-Wefa in 976 A.D.[1] which was quite forgotten when Tycho-Brahe re-discovered it in 1580 A.D. Hence Bhāskara, in 1152 A.D., re-discovered it in India four centuries before Tycho.

Candraśekhara of Orissa on the Moon's Inequalities

In connection with lunar inequalities it is nesefsary here to record what were the equations discovered or verified by M.M. Candraśekhara Siṁha of Orissā in the later half of the last century. He was educated in the orthodox Sanskrit fashion

1. Godfray's *Lunar Theory*, p. 114.

and had no acquaintance with English education. His work *Siddhānta-darpaṇa* was edited by Prof. Jogeschandra Ray, late of the Cuttack College, in 1899.[1] Candraśekhara in his work gives four equations of the Moon which are :-

(1) The equation of apsis.

(2) The Tungāntra equation or the complement of the equation of apsis in combination with evection.

(3) The fortnightly equation or variation.

(4) The Digaṁśa equation or the annual equation (i. e., $\frac{1}{10}$ of the Sun's equation).

(5) The first equation is of the form

$$= \frac{[31^\circ\, 30' - 30' \cos (nt-\alpha)]3438 \times \sin (nt-\alpha)}{360^\circ}$$

$$= -300'\; 49''.5 \sin (nt-\alpha) + 4'\; 46''.5 \sin (nt-\alpha) \cos (nt-\alpha)$$

$$= -300'\; 49''.5 (\sin nt-\alpha) + 2'\; 23''.25 \sin 2 (nt-\alpha)$$

It is seen that Candraśekhara wanted to correct the equation of apsis to the second order of small quantities as in all the Indian authors from Brahmagupta but Candraśekhara's form is correct though his contant is wrong.

(2) His second equation is of the form

$$\frac{160' \times 3438 \sin[\alpha - (\theta + 90^\circ)]}{3438} \times \frac{3438 \sin(D-\theta)}{3438}$$

$$\times \frac{\text{Moon's appt. daily motion}^2}{\text{Moon's mean motion}},$$

$$= -160' \cos (\theta - \alpha) \sin (D-\theta)$$

$$\times \frac{\text{Moon's appt. daily motion}}{\text{Moon's daily mean motion}}$$

Here the constant is the same as that of Śrīpati discussed before. The symbol means the Moon as corrected by the equation of apsis. It is readily seen that the constant of the first term of the equation of apsis is increased by 80'. and that the constant of evection is taken at 80'. In both the cases the error is about +4'.

(3) Candraśekhara's third equation or Variation

$$= \frac{3438' \sin 2(D'-\theta)}{90} = 38'\; 12'' \sin 2(D'-\theta).$$ [3]

1. *Siddhānta-darpaṇa*, V, 100-114.
2. Ibid, VI, 7-9
3. *Siddhānta-darpaṇa* VI. 11-12.

where D' means the Moon as corrected by the 1st and the 2nd equations. Here the constant is wrong by $-1' 18''$.

(4) His fourth equation or the annual equation $=\pm\frac{1}{10}$ of the Sun's equation of apsis,[1]

$$=\pm\frac{1}{10}\times\frac{12\times3438}{360}\sin$$ (Sun's distance from the apogee).

$=\pm11'27''.6 \sin$ (Sun's distance from the apogee).

The modern value of the constant is 11' 10". Tycho found it to be 4' 30". Horrocks' (1639) co-efficient was 11' 51".

As Candraśekhara was aware of Bhāskara's *Bījopanaya*, as also of the work of Śrīpati, his merit here lies in the discovery of the annual equation, and correction to the constant of variation.

Thus we have seen that so far as the luni-solar astronomy is concerned Indian astronomy is independent of Greek astronomy in respect of astronomical constants, that Indian astronomy is generally more accurate than Greek astronomy and that Indian astronomers were not mere "calculators"[2]. There were observers who verified and corrected the old astronomical constants as they came down from Āryabhaṭa and Brahmagupta, who also found independently all the principal equations of the Moon.

1. Siddhānta darpaṇa VI. 13.
2. G.R. Kaye *Hindu Astronomy*, p. 60

—:o:—

Reference

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Karl Manitius's edition : *Syntaxis.*

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CHAPTER VII

Greek and Hindu Methods in Spherical Astronomy

Here we shall reproduce from Sengupta's paper a comparative account of the Greek and ancient Indian methods in Spherical Astronomy and to bring out the independence of the Indian Astronomers on this subject. The views on this subject would necessarily differ from those of many European scholars such as Colebrooke and Bentley (early 19th century) to Kaye (early 20th century). Kaye wrote as follows in the *Journal of Asiatic Society of Bengāl* 1919, No. 3.

> The methods by which (the rules) were obtained are buried in obscurity. Braunmühl[1] has stated "that the Indians were the first to utilise the method of projection in the Analemma of Ptolemy." It is intended to present the Hindu methods as clearly as possible and to show that Braunmühl has not done sufficient justice to the Indian astronomers.

As to Kaye, we shall show that his remark quoted above is due to the fact that he had to rely mostly on the English translation of the *Sūryasiddhānta* of Burgess, and perhaps he had no access to the works of Bhāskara II (1150 A.D.), who was the first to explain the ancient Indian methods clearly.

Greek and Hindu Methods in Spherical Astronomy

Of the Greek methods in Spherical Astronomy, the history begins with elementary principles only from Euclid (300 B.C.). Even in Theodosius' *Sphaerica*[2] (about 153 B. C.) "there is nothing that can be called trigonometrical." Heath again says,

1. Heath, *Greek Mathematics*, Vol. II. p. 291. Braunmuhl, *Geschichte der Trigonometrie*, pp. 38-42.
2. Heath, *Greek Mathematics*, Vol. II, p. 250.

"the early spheric did not deal with the geometry of the sphere as such, still less did it contain anything of the nature of the spherical trigonometry. (This deficiency was afterwards made good by Menelaus's *Sphaerica*).[1] Hence the Greek spherical trigonometry began with Menelaus (90 A.D.). His theorem in geometry is well-known—"If the sides of a plane triangle be cut by a transversal into six segments, the continued product of any three alternate segments, is equal to the continued product of the remaining three." From this proposition he deduced the so-called "*regula sex quantitatum*" or the theorem, if the sides of a spherical triangle be cut by an arc of a great circle into six segments, the continued product of the chords of the doubles of any three alternate segments is equal to the continued product of the chords of doubles of the remaining three segments." In plane geometry if the sides BC, CA, AB of a triangle be cut by any transversal at L, M, N, respectively, then we have

$$\frac{BL}{LC}\cdot\frac{CM}{MA}\cdot\frac{AN}{NB}=1.$$

In spherics the theorem is :

$$\frac{\text{Chord } 2\,BL}{\text{Chord } 2\,LC}\cdot\frac{\text{Chord } 2\,CM}{\text{Chord } 2\,MA}\cdot\frac{\text{Chord } 2\,AN}{\text{Chord } 2\,NB}=1$$

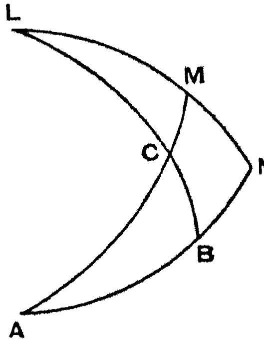


Fig. 5

Both these theorems are proved in Ptolemy's *Syntaxis* (Karl Manitius's edition, Vol. I, pp. 45-51).

If R be the radius of the sphere on which the spherical triangle ABC is constructed, then the chord of the arc 2 BL= 2 R sin BL. Hence Menelaus's theorem in spherics may be expressed as follows :

$$\frac{\text{Sin } BL}{\text{Sin } LC}\cdot\frac{\text{Sin } CM}{\text{Sin } MA}\cdot\frac{\text{Sin } AN}{\text{Sin } NB}=1$$

This theorem is true for any spherical triangle.

If $\angle B=AN=AM=90^\circ$ and L the pole of AB, then LMN is a secondary to the arc AB. There are four arcs of great circles; taking any three as forming a spherical triangle and the fourth as the transversal we readily get for the right-angled

1. A.A. Bjornbo, "*Studien über Menelaos' Sphärik*" in Abhandlungen Zur Geschichte der Mathematischen Wissenchaften for 1902, pp. 89 *et seq.*; also Heath, *Greek Mathematics*, vol. II p. 261-73.

triangle ABC, the relations :—

(i) $\sin a = \sin b \sin A$

(ii) $\sin c = \tan a \cot A$

(iii) $\cos b = \cos a \cos c$

(iv) $\tan c = \tan b \cos A$

The above are some of the Napier's rules for a right-angled spherical triangle, deducible from Menelaus's theorem[1]. They are generally sufficient in the case of such triangles. In any spherical triangle, however, this theorem of Menelaus does not in any single step lead to any of the equivalents of the time-altitude or altazimuth equations in spherical astronomy. The ancient Indian methods, though none of them are so highly finished as Menelaus's theorem, yet are not less powerful in tackling the problems that arise in astronomy in connection with the apparent diurnal motion of the heavens. The Greek or Ptolemaic method presents no further points of interest except in its application. We now proceed to illustrate the ancient Indian methods and shall refer to the Ptolemaic method as occasion arises.

Ancient Indian Methods in Spherical Astronomy

In the Indian methods there is no general rule to follow. It is by properties of similar right-angled triangles that a fairly complete set of accurate formulae are obtained. These right-angled plane triangles are classified under the names,—'Krānti-kṣetras' (triangles of declination) and 'Akṣa-kṣetras' (triangles of latitude). We consider the following problems :—

Problem :- To find the time of rising on the equator of a length l, of arc of the ecliptic measured from the first point of Aries.

Let ω be the obliquity of the ecliptic and R. A. the right ascension corresponding to the longitude l, and δ the corresponding declination. The Indian form of the equation is :

1. Three more can be deduced similarly, namely,

(v) $\sin c = \sin b \sin C$

(vi) $\sin a = \tan c \cot C$

(vii) $\tan a = \cos C \tan b$.

*$R \sin R.A. = \dfrac{R \sin l \times R \sin \omega}{R \cos \delta}$, where R is the radius of the sphere.

Note:— If R be the radius of the circle of reference, the Indian trigonometrical functions for the arc θ, are (1) the 'sine,' (2) the 'cosine' and (3) the versed sine. They are respectively equal to $R \sin \theta$, $R \cos \theta$ and $R \text{ vers } \theta$.

In the adjoining figure, O is the centre of the armillary sphere, ϒQ, ϒC are quadrants of the equator and the ecliptic, respectively. P is the celestial pole, PCQ the summer solstitial colure. Join Oϒ, OQ, OP and OC.

Let ϒS be $=l$, ϒM=R.A., CQ=∠SϒM$-\omega$, SM$=\delta$.

Join OS, OM. PSM is the secondary to the equator.

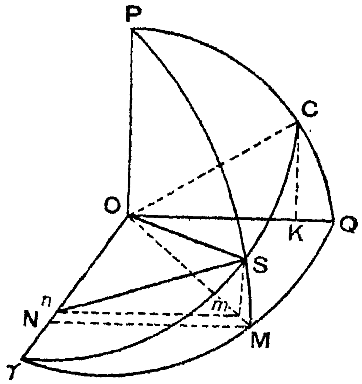


Fig. 6

From C draw CK perpendicular to OQ. From S draw *Sm* and *Sn* perpendicular to OM and Oϒ, respectively. Join MN and from M draw MN perpendicular to Oϒ.

Then the triangles *Smn* and CKO are similar. They are called '*Krānti-kṣetras*'[1] or declination triangles,—similar right-angled triangles having one acute angle$=\omega$.

$\therefore \quad Sm : Sn = CK : OC$

or $\quad R \sin \delta : R \sin l = R \sin \omega : R$

$$R \sin \delta = \frac{R \sin l \times R \sin \omega}{R} \qquad \text{......(I)}$$

The *Aryabhaṭīya, Gola*, 25. Varāhamihira, in the *Pañcasiddhāntikā* (IV. 92) states it in the form $2R \sqrt{\dfrac{(R^2 \text{ Sin }^2 l) - R^2 \text{ Sin }^2 \delta}{2R \cos \delta}}$

=R Sin R.A., which is evident from figure. Brahmagupta's equation is identical with that of Āryabhaṭa, (*BrSpSi.* III. 15, *Sūrya-siddhānta* III. 40-41.

Also Bhāskara II, *Grahagaṇita* cap. VIII, stanzas 54-55, is in agreement with Varāhamihira's forms.

Greek Method

In the same figure[1] let PSC be the triangle and ϒMQ be the transversal. Then Menelaus's theorem gives

$$\frac{\sin PM}{\sin MS}\times\frac{\sin S\gamma}{\sin \gamma C}\times\frac{\sin CQ}{\sin QP}=1$$

or $$\frac{1}{\sin\delta}\times\frac{\sin l}{1}+\frac{\sin \omega}{1}=1$$

or $$\sin \delta=\sin l\times\sin \omega.$$

Indian Method

Again by the Indian method from the same two similar triangles we get

$$mn : \text{nS}=\text{OK} : \text{OC}$$

or, $$mn : \text{R} \sin l=\text{R}\cos \omega : \text{R}$$

$$\because \quad mn=\frac{\text{R}\sin l\times\text{R}\cos\omega}{\text{R}}$$

Again MN : mn=OM : Om

i.e., $\text{R}\sin \text{R. A.} : mn=\text{R} : \text{R}\cos\delta$

$$\therefore \quad \text{R}\sin \text{R.A.}=\frac{\text{R}\sin l\times\text{R}\cos\omega}{\text{R}\cos\delta}$$

Greek Method

· Take PQM for the triangle and γSC for the transversal.

Then, $$\frac{\sin PC}{\sin CQ}\times\frac{\sin Q\gamma}{\sin \gamma M}\times\frac{\sin MS}{\sin SP}=1$$

or $$\frac{\cos\omega}{\sin\omega}\times\frac{1}{\sin \text{R.A}}\times\frac{\sin\delta}{\cos\delta}=1$$

or $$\sin \text{R.A.}=\tan\delta\cot\omega,$$

The Indian form of the equation is different from that of Ptolemy's. It is also better for the purpose of calculation.

Note :—From the same two similar triangles we have

$$On : \text{ON}=\text{R}\cos\delta ; \text{R}$$

$$\therefore \quad On : \text{R}\cos l=\frac{\text{R}\cos \text{R.A.}\times\text{R}\cos\delta}{\text{R}} \quad ......(3)$$

Again, $$\tan \text{R.A.}=\frac{mn}{on}$$

$$=\frac{\text{R}\sin l\times\text{R}\cos\omega}{\text{R}\times\text{R}\cos l} \quad ......(4)$$

Again, $mn : Sm$=OK : KC

1. Manitius' Edition of *Syntaxis*, I. 51-53.

or $mn = \frac{R \sin\delta \times R \cos\omega}{R \sin \omega}$

$\therefore \quad R \sin R.\ A. = \frac{MN}{mn} \times mn = \frac{R}{R \cos\delta} \times \frac{R \sin\delta \times R \cos\omega}{R \sin \omega} \quad (5)$

Problem II :—

Sidereal Time-intervals

Indian Method

The problem discussed above provides the method of finding the sidereal time-intervals in which the signs of the zodiac rise on the equator. To find the corresponding times at any latitude ϕ, it is necessary to calculate and apply what is the ascensional difference due to the elevation of the celestial pole. This ascensional difference is called '*carakāla*' or the variation in the length of half the day. The 'sine' of this '*carakāla*' is called '*carajyā*.' If *ch* denotes this '*carakāla*,'

then,[1] $R.\ \text{Sin}\ ch = \frac{R \sin\phi \times R \sin \delta \times R}{R \cos \phi \times R \cos \delta}$

Just as in the solution of the previous problem, the declinational triangles or '*Krānti Kṣetras*' were constructed and used, so in the solution of this and other problems another set of similar triangles were conceived and constructed and were given the name '*Akṣa kṣetras*.[2]

Let NPZH be the meridian (Fig.7), NOH the north-south line passing through the observer O, P the celestial pole, OQ the trace of the equator on the meridian plane, Z the zenith. Join OZ. From Q draw QM perpendicular to OZ. Then the triangle QOM is an '*Akṣa-kṣetra*' or a latitudinal right-angled triangle, as $\angle QOM = \phi$, the latitude of the station. Another '*Akṣakṣetra*' is thus

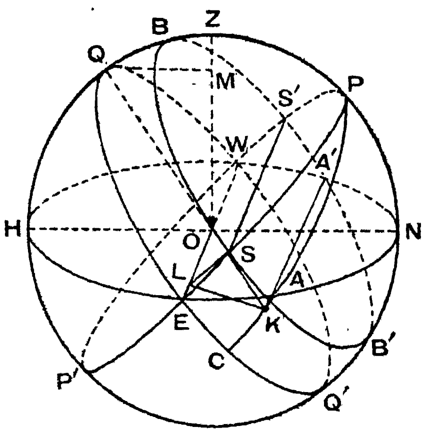


Fig 7

conceived, in the same figure, let P, P′ be the north and south celestial poles, N, the north point, AB A′B′ the diurnal

1. *Āryabhaṭīya*, Gola, 26; *Pañca-siddhāntikā*, IV, 34; *Brāhmasphuṭasiddhānta*. II, 57-58; *Sūrya-siddhānta*, II, 91; *Grahagaṇita*. VIII. 48-49.

2. Bhāskara, *Goladhyāya* (Wilkinson and Bāpūdeva Śāstri's tr.) PP. 173-76; also, Bhāskara, Grahaganita, Ch. IX. 13-17.

circle of a heavenly body with declination δ, NEHW the horizon, PEP′ W the six O′ clock circle. Here AA′ the line of intersection of the diurnal circle with the horizon is called the "*udayāsta-sūtra*"[1] (or the thread joining the rising and setting points). SS′ the line of interesection of the diurnal circle and the six o′ clock circle, is the horizontal diameter of the diurnal circle. From S draw SK and SL perpendiculars respectively to AA′ and EW. Join KL.

Now since PN=ϕ, the latitude of the station, in the small right-angled triangle KLS, the $\angle$ KLS is also=ϕ.

$$\therefore \quad SK : SL = QM : MO$$

$$\text{or} \quad SK = \frac{SL \times QM}{MO} = \frac{R \sin \delta \times R \sin \phi}{R \cos \phi}$$

Now SK[2] is a "sine" in the small circle AB A′B′ of which the radius is R cos δ; this "sine" reduced to the equator (radius R) is the 'sine' of *cara*.

$$\therefore \quad R \sin ch = R \sin EPA$$

$$= \frac{R \sin \delta \times R \sin \phi \times R}{R \cos \phi \times \cos \delta}$$

Greek Method

Let[3] the arc PA be produced to meet the equator at C. Take PCQ′ for the triangle and EAN for the transversal. Then we get,

$$\frac{\sin PA}{\sin AC} \times \frac{\sin CE}{\sin EQ'} \times \frac{\sin Q'N}{\sin NP} = 1$$

$$\text{or} \quad \frac{\cos \delta}{\sin \delta} \times \frac{\sin CE}{1} \times \frac{\cos \phi}{\sin \phi} = 1$$

$$\therefore \quad \sin CE = \sin ch = \frac{\sin \phi \times \sin \delta}{\cos \phi \times \cos \delta}.$$

Note—The perpendicular distance between AA′ and Ew is called the 'sine' of the amplitude or the '*Agrā*' which is thus calculated :—

$$KL : LS = QO : OM$$

$$\therefore \quad {}^{4}R \sin \text{amplitude} = \text{'}Agr\bar{a}\text{'} = KL$$

$$= \frac{LS \times QO}{OM} \quad = \frac{R \sin \delta \times R}{R \cos \phi}$$

It is now evident that the ancient Indian method is different

1. Bhāskara, *Gola*, VII, 39.
2. This is called by the name '*kujyā*' or '*kṣitijyā*'. i, e., earth-sine. Āryabhaṭa, *Gola*, 26, Brahmagupta, II, 57, *Sūrya-siddhānta*, *II*, *61 etc.*
3. Manitius, ibid, p. 84.
4. Āryabhaṭa, *Gola*. 30, etc.

from the Greek method in this case also. As the triangle KLS is difficult to show in the diagram, it is shown in its projection on the meridian plane in Burgess's translation of the "*Sūrya-siddhānta*,"(page 232)and also in Wilkinson and Bāpūdeva Śāstrī's translation of the '*Siddhānta Śiromaṇi*,' p. 175. This has led Braunmühl to assume that the Indian method of arriving at the equation of ascensional difference and some other equations of spherical astronomy has its origin in the Analemma of Ptolemy. A careful study, however, does not justify the identification of Indian methods with the graphic method of the Analemma, which is deduced from the projections of the position of a heavenly body on the meridian prime vertical and the horizon. It is being presently shown that what was done out of difficulty in drawing the figures properly has been taken by Braunmühl as a Greek connection.

Problem III[1] :—

To find the "Time-altitude" Equation

If from any point S on the diurnal circle a perpendicular be drawn to the *Udyāsta-Sūtra* spoken of before, this perpendicular is called the *cheda* or '*iṣṭahṛti*.' The perpendicular from S on the horizon is called '*Śaṅku*'[2] the sine of the altitude. The line joining the foot of the '*Śaṅku*' and that of the perpendicular on the '*Udayāsta-Sūtra*' goes by the name of '*Śaṅkutala*' and this *Śaṅkutala* lies to the south of the '*Udayāsta-Sūtra*' during the day.

In this figure (Fig 8) if AA′ be the 'Udayāsta-Sūtra' or the intersection of the diurnal circle and the horizon, and S a point on the diurnal circle denoting a position of the Sun, SK, SL perpendiculars on AA′ and the horizon respectively; SL is called the '*Śaṅku*,' SK the '*cheda*' and LK, the '*Śaṅkutala*'. In this triangle KSL, the angle KSL was recognised to be the latitude of the station.

Thus the triangle SKL is not taken in its projection on the meridian plane. The side SK is taken as formed of two parts.

---

1. Āryabhaṭa could not arrive at the true equation. Cf. Gola 28. The correct rules occur in *Pañcasiddhāntikā*, IV, 42. 44; *Brāhmasphuṭasiddhānta*. III, 36-38, 26-40 ; *Sūryasiddhānta*, III, 34-35.

2. Bhāskara says : ग्रहस्थानाल्लम्बः शंकुः । तस्यतलमुदयास्तसूत्राद्दक्षिणतो भवति ॥ "*Gola*, VIII-39-41, Āryabhaṭa uses the term शङ्क्वग्रम्" *Gola*, 29.

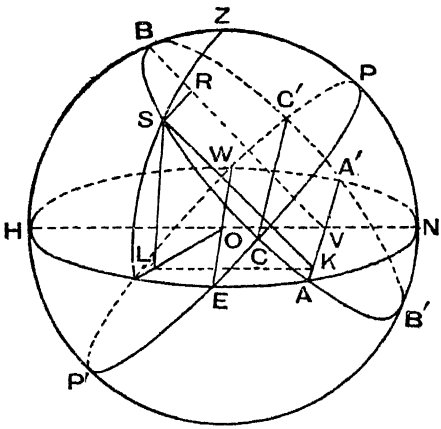


Fig. 8

Let CC′ be the line of intersection of the diurnal circle and the 'six o'clock 'circle EPW. Let SK cut CC′ in M. Then.

$$SK = SM + MK$$

Here SM, the 'sine' in the diurnal circle of the complement of the hour angle is given a distinct name '*Kalā*'[1] and MK as explained before is known by the name '*Kujyā*.' This '*Kalā*' is constructed from the point S in the diurnal circle. Thus the triangles like SKL were not taken in their projections on the meridian plane as Braunmühl would suggest.

From the triangle KSK, we get,

'*Cheda*' : '*Śaṅku*' $= R : R \cos\phi$ where ϕ is the latitude of the observer;

'*Śaṅku*' is here $= R \cos Z$, Z being the Sun's zenith distance.

$$\therefore \quad \text{'cheda'} = \frac{R \cos Z \times R}{R \cos \phi}$$

Now '*Cheda*' = radius of the diurnal circle + *Kujyā*—versed sine of the hour-angle in the diurnal circle O′ B+O′ V−BR,

$$= R \cos \delta + \frac{R \sin \delta \times R \sin \phi}{R \cos \phi} - \frac{R \text{ vers } H \times R \cos \delta}{R}$$

As in the previous problem, $Kujy\bar{a} = SK = \dfrac{R \sin \delta \times R \sin \phi}{R \cos \phi}$

$$\text{or} \quad \frac{R \cos Z \times R}{R \cos \phi} = \frac{R \cos \delta}{R} \left\{ R + \frac{R \sin \delta \times R \sin \phi}{R \cos \phi} \times \frac{R}{R \cos \delta} - R \text{ vers } H \right\}$$

The above equation simplified becomes

$\cos Z = \sin\delta \sin\phi + \cos\delta \cos\phi \cos H.$

In this connection we consider the altazimuth equation by the Indian method.

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1. Bhāskara's *Grahagaṇita*, VIII, 55.

O′ is the middle point of CC′ or it is the centre of the diurnal circle ABB′.

Problem IV :—[1]

The Altazimuth Equation

Indiad Method

Let α denote the azimuth of the Sun from the south. In the same triangle SKL in the same figure, we have,

$$LK : SL = R \sin \phi : R \cos \phi$$

or, $\text{`}\acute{S}a\dot{n}k\bar{u}tala\text{'} : \text{`}\acute{S}a\dot{n}ku\text{'} = R \sin \phi : R \cos \phi$

$$\therefore \quad \text{`}\acute{S}a\dot{n}kutala\text{'} = \frac{R \cos Z \times R \sin \phi}{R \cos \phi}$$

Now '*Śaṅkutala*' is made up of two parts, namely, '*Bāhu*' and '*Agrā*,' of which the former is the distance of L from the observer's East-West line; the 'Agrā' has been already found.

$$\text{Here `}B\bar{a}hu\text{'} = \frac{R \sin Z \times R \cos \alpha}{R} \text{ and `}Agr\bar{a}\text{'} = \frac{R \sin \delta \times R}{R \cos \phi}$$

$$\therefore \quad \text{`}Sa\dot{n}kutala\text{'} = \text{`}B\bar{a}hu\text{'} + \text{`}Agr\bar{a}\text{'}$$

$$\text{or} \quad \frac{R \cos Z \times R \sin \phi}{R \cos \phi} = \frac{R \sin Z \times R \cos \alpha}{R} + \frac{R \sin \delta \times R}{R \cos \phi}$$

$$\text{or } R \sin \delta = \frac{R \cos \phi}{R} \left(\frac{R \cos Z \times R \sin \phi}{R \cos \phi} - \frac{R \sin Z \times R \cos \alpha}{\phi} \right)$$

which is easily seen to be equivalent to

$$\sin \delta = \cos Z \sin \phi - \sin Z \cos \phi, \cos \alpha$$

Greek Method

Ptolemy[2] has also a method of finding the Sun's altitude at any hour of the day. His method is as follows :—

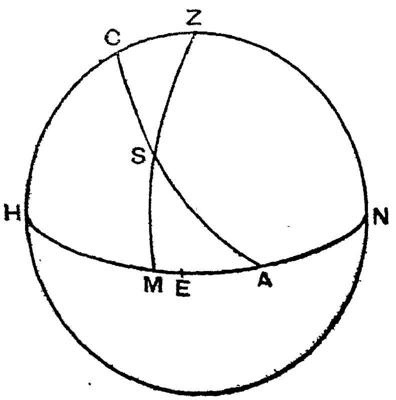


Fig. 9

(i) He would find by means of his tables for the times of risings of the signs of the zodiac, the orient ecliptic point. (ii) He would then find the culminating point of the ecliptic. (iii) He would finally apply Menelaus's theorem in sphrerics thus :—

Let ASC be any position of the ecliptic,(Fig. 9)NZC the

1. The equivalent of this, in a particular case, is first found in *Brāhma. sphuṭasiddhānta*, Ch. III, 54-56 Cf. *Sūryasiddhānta*, III, 28-31, also Bhāskara *Grahagaṇita*, IX. 50-52.

2. Manitius, ibid, pp. 118, 19.

meridian, NAMH the horizon, Z, the zenith and S the Sun. Here the celestial longitudes of C, S and A are taken to be known; hence ZC and CH are also known.

Now take ZCS for the triangle and HMA to be the transversal ; we then have by Menelaus's theorem.

$$\frac{\sin ZH}{\sin HC}\times\frac{\sin CA}{\sin AS}\times\frac{\sin SM}{\sin MZ}=1$$

$$\text{or } \sin SM=\frac{\cos CZ\times\sin AS}{\sin CA}$$

It is thus clear that Ptolemy had no direct method for connecting the Sun's altitude and the hour-angle. This method is workable for the problem "given time, find the altitude" but is not workable in the converse problem ; besides, the calculation of the longitudes of A and C is very cumbrous.

Again, when EA has been found out, taking ZHM for the triangle and CSA for the transversal, we get,

$\frac{\sin HA}{\sin Am}\times\frac{\sin MS}{\sin SZ}\times\frac{\sin ZC}{\sin CH}=1$, whence and thence HM, the azimuth can be found. The method is here also cumbrous, there being no direct connection between altitude and azimuth ; besides the time-element is not avoided.

The Analemma of Ptolemy and the Indian Method.

When the Sun's declination is zero and his hour-angle, is H, Zeuthen[1] following the method of the 'Analemma' of Ptolemy, as explained by Braunmühl[2] has deduced the following equations:

(1) $\cos Z=\cos H.\cos\phi$

(2) $\tan\alpha=\frac{\tan H}{\sin\phi}$

To these two, Heath following Braunmühl, adds

(3) [3]$\tan ZQ=\frac{\tan H}{\cos\phi}$

1. Heath, *Greek Mathematics*, Vol. II. pp, 290-91.
   Zeauthen, *Bibliotheca Mathematica*, 1_3, 1900, pp. 23-27.
2. Braunmühl, ibid, pp. 12-13,
3. The Indian form of this equatiom is R Ṣin ZQ $=\dfrac{R\text{ Sin }H\times R}{\dfrac{\sqrt{R^2-R^2\cos^2H\times R^2\text{ Sin}^2\phi}}{R}}$

Bhāskara's, *Golādhyāya*, Com. on VIII, 67.

where Z is the zenith and Q is the point of intersection of the prime vertical and its secondary passing through the Sun and the north-south points.

Zeuthen[1] points out that later in the same treatise Ptolemy finds the arc 2β described above the horizon by a star of given declination δ' by a procedure equivalent to the formula.

(4) $\cos\beta = \tan\delta' \tan\phi$.

With regard to the 'Analemma' of Ptolemy. it may be noted, as Heath[2] says, that "the procedure amounts to a method of graphically constructing the arcs required as parts of an auxiliary circle in one plane." Many things may be, in practice, done graphically far more easily than by the theoretical method. Besides, no theoretical calculations occur in the 'Analemma'. Zeuthen[2], following the method of this work, has deduced in the general case, the two equations.

(5) $\cos Z = (\cos\delta, \cos H + \sin\delta.\ \tan\phi)\ \cos\phi$.

(6) $$\tan\alpha = \frac{\cos\delta.\sin H}{\frac{\sin\delta}{\cos\delta} + (\cos\delta.\cos H + \sin\delta.\tan\phi)\sin\phi}$$

These equations are suggested to a modern reader from a study of the figures in the 'Analemma.' But neither in this work nor in the '*Syntaxis*' are they to be found. With regard to the first four formulae, it is possible that they were recognised by Ptolemy. With regard to the last two, Zeuthen[3] remarks "mais le texte nen contient rien,' and they were certainly not recognised by Ptolemy.

Besides the tangent function is wholly absent in Greek trigonometry. They are also different in form from those arrived at by the Indian method as explained before. Thus, it is clear that the Indian methods are in no way connected with the method of the 'Analemma.'

Even taking for granted that the Indians followed a method of projection much allied to the method of the Analemma' there is no adequate reason for assuming that their method is derived from any Greek source. Analogy and precedence do not necessarily constitute originality—there is still the chance of a remoter origin from which both the systems drew their inspiration. The method of the 'Analemma,' as has been already stated, presents a

1, 2, Bjornbo. *loc. cit.* p. 86.

3. Zeuthen, *loc. cit.* p. 27.

graphical method for constructing the Sun's altitude and azimuth from the hour angle when the Sun's declination is zero but such a graphical method is generally complex as compared with the elegant Indian method. An astronomer who constructs and uses an armillary sphere to arrive at his equations in spherical astronomy and who has not a well-developed spherical astronomy at his command must have to draw perpendiculars from the positions of the heavenly body, not only on the meridian plane, the horizon or on the prime vertical, as the occasion arises, but also on the line of intersection of the diurnal circle with the horizon. Hence Braunmühl's statement that the Indian methods of spherical astronomy have their origin in the 'Analemma's, in spite of his admitting that Indians were first to utilise its methods, is rather far-fetched and tends to take away the honour from the great Indian astronomers, who devised the beautiful methods. The 'Analemma' as it now exists is a Latin translation from an Arabic version of the original Greek[1]. We may reasonably doubt that the Arabic version was greatly influenced by the ancient Indian system.

We now pass on to the consideration of other allied or similar problems in the two systems of astronomy.

Problem V—

To find the Angle between the Ecliptic and the Meridian

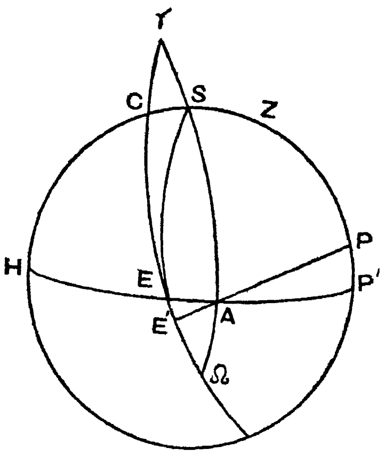


Fig. 10

Indian Method[2]

Let ♈SA be thee cliptic, ♈CE the equator, E the east-point of the horizon (Fig 10). Cut off SH=90° and draw the great circle HEAP′ cutting the meridian P′SCH at the points P′ and H. The aim is to find AP′ but it is enough to find EA since AP′ is the complement of EA′.

Both Āryabhaṭa and Brahmagupta were unable to find EA correctly. Let P be the celestial pole and let PAE′ be

1. On the influence of the ancient Indians on Arab mathematics and astronomy; see Alberuni's India, translated by Dr. E. Sachau, Vol. II, p. 304.

2. Āryabhaṭa, Gola, 45; *BrSpSi*, IV. 17; *Sūrya-siddhānta*, IV. 25; Bhāskara's *Golādhyāya*, VIII. 21-74, first example in his own commentary.

the secondary to the equator cutting it at E'. Both the above astronomers were content with the idea that AE=AE', or that AE=the declination of the point A of the ecliptic which is 90° ahead of S in the above figure. This idea continued till the time of Bhāskara II (1150 A. D.) who found out the correct equation.

He recognised that CS, the declination of S=PP'; P'EH is then the horizon of the station whose north geographical latitude is CS. Also, the 'sine' of EA is the '*Agrā*' or the sine of the amplitude of the point A for the latitude CS.

$$\therefore R\sin EA=\frac{R\sin AE'\times R}{R\cos CS}=\frac{R\sin(90^\circ+\gamma S)\times R\sin\omega}{R}\times\frac{R}{R\cos CS}$$

$$\text{or } R\sin EA=\frac{R\sin(90^\circ+l)\times R\sin\omega}{R\cos\delta}$$

where l stands for γS and δ for CS.

Greek Method :

We give below the Ptolemy's method in a slightly modified form[1]. Let SHA be the triangle and γCE be the transversal ; then we have,

$$\frac{\sin SC}{\sin CH}\times\frac{\sin HE}{\sin EA}\frac{\sin A\gamma}{\sin \gamma S}=1$$

$$\text{or } \frac{\sin\delta}{\cos\delta}\times\frac{\sin 90^\circ}{\sin EA}\times\frac{\sin(90^\circ+l)}{\sin \iota}=1$$

$$\therefore \sin EA=\frac{\sin\delta\times\sin(90^\circ+l)}{\cos\delta\times\sin l},$$

which is readily transformed into Bhāskara's equation. The originality of Bhāskara would be readily admitted.

Problem VI—

To find the Angle between the Ecliptic and the Horrizon

Indian Method :

(A) Āryabhaṭa's method. It consists of the following[2] steps :—

(1) Determination of the orient point of ecliptic.

(2) Finding the sine of its amplitude.

1. Manitius, *ibid*, Book I, pp. 104-06.
2. Āryabhaṭa, *Gola*, 33 : *Sūryasiddhānta*, V. 5-6.

(3) Determination of the culminating point of the ecliptic from the hour-angle of the Sun.

(4) Finding the declination of the culminating point of the ecliptic.

Having obtained the above elements, his rule can be followed thus :

In this Fig. 11 NZH is the meridian, HMEAN the horizon, CN′A the ecliptic. If N′ be the nonagesimal or the highest point of the ecliptic, the altitude of N′ is the inclination of the ecliptic to the horizon.

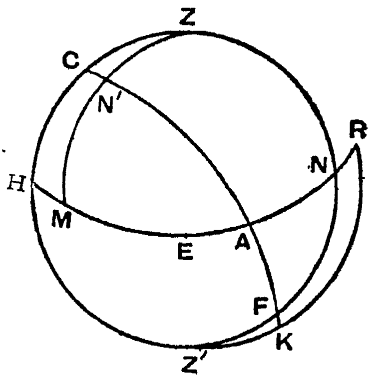


Fig. 11

Let ZN′M be the vertical through N′, meeting the horizon at M.

When the time is given, the longitudes of A and C can be found out, from which CZ the zenith distance of C and EA the amplitude of the orient ecliptic point can be determined.

Here HM=EA.

According to Āryabhaṭa,

$$R \sin CN' = \frac{R \sin CZ \times R \sin HM}{R}$$

and $R \sin ZN' = \sqrt{(R \sin CZ)^2 - (R \sin CN')^2}$

This is only an approximate rule. As expressed here,

$$R \sin ZN' = \frac{R \sin CZ \times R \cos HM}{R} \text{ approximately.}$$

$$= \frac{{}^1R \sin CZ \times R \cos HM \times R}{R \times R \cos CN'} \text{ accurately.}$$

$$= \frac{R \sin CZ \times R \cos HM}{R \cos CN'}.$$

(B) The method of Brahmagupta[2] :

Brahmagupta would also first determine the orient ecliptic

1. This correction was perhaps first noticed by Raṅganātha (1603 A. D.) in his commentary in the *Sūryasiddhānta*.

2. *BrSpSi.* V 3.

point A. Then he subtracts 90° from the longitude of A. Thus having the longitude of N′, he next finds the part of the day elapsed of N′ ; from which by the time-altitude equation discussed above, he finds ZN′. This is of course more accurate than that of Āryabhaṭa. Bhāskara[1] here follows Brahmagupta.

Greek Method :

Let the ecliptic CN′A cut the lower half of the meridian at F. Ptolemy takes AK along the ecliptic=90° and AR along the horizon=90°; then the great circle passing through R and K passes through the nadir Z′. Now take Z′FK for the triangle and ANR for the transversal, then by Menelaus's theorem.[2]

$$\frac{\sin FN}{\sin NZ'} \times \frac{\sin Z'R}{\sin RK} \times \frac{\sin KA}{\sin AF} = 1$$

$$\therefore \sin RK = \frac{\sin FN}{\sin AF} = \frac{\cos FZ'}{\sin AC} = \frac{\cos CZ}{\sin AC} = \frac{\sin CH}{\sin AC}$$

$$\text{or } \sin MN' = \frac{\sin CH}{\sin AC}.$$

Here Ptolemy's equation is simpler than that of Āryabhaṭa; hence they must be independent of each other.

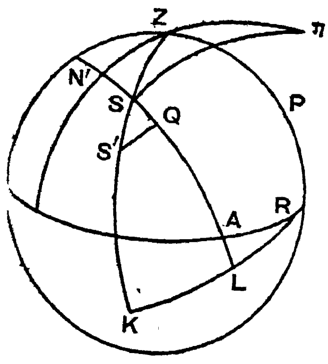


Fig. 12

Problem VII:—

To find the Angle made by the Vertical through any Point of the Ecliptic with the Latter

This problem is considered by Ptolemy but it is not considered separately in Indian Astronomy, but from the rule for parallax in longitude, the rule for its calculation can be deduced.

Indian Method :

In Fig. 12 S represents the true position of the Sun and S′ the Sun's position as depressed by parallax. N′SA is the ecliptic. If from S′, S′Q be drawn perpendicular to the ecliptic, then, if P is the horizontal parallax,

1. *Grahagaṇita*; XII, 3-4.
2. Manitius, *ibid.* pp. 110-111.

$$SQ = SS' \times \frac{R\cos S'SQ}{R} = \frac{P \times R\sin ZS}{R} \times \frac{R\cos S'SQ}{R}$$

$$^{1} = \frac{P}{R}\sqrt{(R\sin ZS)^2 - (R\sin ZN')^2}$$

$$^{2} = \frac{P}{R^2} \times R\sin N'S \times R\cos ZN',$$ where N' is the nonagesimal

Thus R cos S'SQ is seen to be

$$= \frac{R\sin N'S \times R\cos ZN'}{R\sin ZS}$$

The Indian method is fully described by Bhāskara in his '*Golādhyāya*. VIII, 12-25. The truth of the Indian rule for R cos S'SQ is easily seen from the spherical triangle AZS, where A is the pole of the ecliptic.

Greek Method :

[3]Ptolemy takes SK and SL 90° each, along the vertical circle ZSEK and the ecliptic N'SA. The great circle through K and L cuts the horizon at R which is the pole of the vertical circle. He takes SKL for the triangle and EAR for the transversal, then

$$\frac{\sin SE}{\sin EK} \times \frac{\sin KR}{\sin LR} \times \frac{\sin LA}{\sin AS} = 1$$

or $$\sin LR = \frac{\cos ZS \times \cos AS}{\sin ZS \times \sin AS}$$

or $$\cos S'SQ = \cot ZS \times \cot AS = \tan SE \times \cot AS.$$

The Indian and the Greek rules are altogether different both in form and method. There can, therefore, be no question of any connection between them.

Problem VIII :—

To convert the Celestial Longitude of a Heavenly Body into its Polar Longitude

If σ be the position of a (Fig.13), γK and σK are the celestial longitude and the celestial latitude, respectively ; γM and σM are the polar longitude and polar latitude ; γN and σV are the right ascension and declination of the star.

Indian Method :

All Indian astronomers attempt at finding MK which sub-

1. Āryabhaṭa, *Gola*, 34; *Pañcasiddhāntikā*, IX, 22 *BrSpSi*, XI, 23.
2. *BrSpSi*. V, 4-5 ; *Sūryasiddhānta*, V, 7-8 Bhāskara, *Grahagaṇita*, XII, 4.
3. Manitius, ibid, p. 119.

point A. Then he subtracts 90° from the longitude of A. Thus having the longitude of N′, he next finds the part of the day elapsed of N′ ; from which by the time-altitude equation discussed above, he finds ZN′. This is of course more accurate than that of Āryabhaṭa. Bhāskara[1] here follows Brahmagupta.

Greek Method :

Let the ecliptic CN′A cut the lower half of the meridian at F. Ptolemy takes AK along the ecliptic=90° and AR along the horizon=90°; then the great circle passing through R and K passes through the nadir Z′. Now take Z′FK for the triangle and ANR for the transversal, then by Menelaus's theorem.[2]

$$\frac{\sin FN}{\sin NZ'} \times \frac{\sin Z'R}{\sin RK} \times \frac{\sin KA}{\sin AF} = 1$$

$$\therefore \sin RK = \frac{\sin FN}{\sin AF} = \frac{\cos FZ'}{\sin AC} = \frac{\cos CZ}{\sin AC} = \frac{\sin CH}{\sin AC}$$

$$\text{or } \sin MN' = \frac{\sin CH}{\sin AC}.$$

Here Ptolemy's equation is simpler than that of Āryabhaṭa; hence they must be independent of each other.

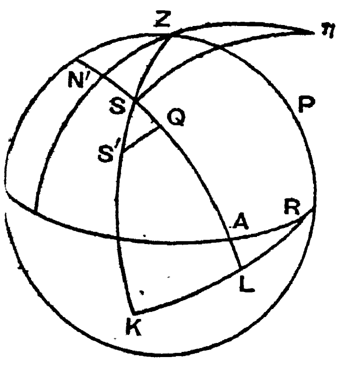


Fig. 12

Problem VII:—

To find the Angle made by the Vertical through any Point of the Ecliptic with the Latter

This problem is considered by Ptolemy but it is not considered separately in Indian Astronomy, but from the rule for parallax in longitude, the rule for its calculation can be deduced.

Indian Method :

In Fig. 12 S represents the true position of the Sun and S′ the Sun's position as depressed by parallax. N′SA is the ecliptic. If from S′, S′Q be drawn perpendicular to the ecliptic, then, if P is the horizontal parallax,

1. *Grahagaṇita*; XII, 3-4.
2. Manitius, *ibid.* pp. 110-111.

$$SQ=SS'\times\frac{R\cos S'SQ}{R}=\frac{P\times R\sin ZS}{R}\times\frac{R\cos S'SQ}{R}$$

[1] $$=\frac{P}{R}\sqrt{(R\sin ZS)^2-(R\sin ZN')^2}$$

[2] $$=\frac{P}{R^2}\times R\sin N'S\times R\cos ZN',$$ where N′ is the nonagesimal.

Thus R cos S′SQ is seen to be

$$=\frac{R\sin N'S\times R\cos ZN'}{R\sin ZS}$$

The Indian method is fully described by Bhāskara in his '*Golādhyāya*. VIII, 12-25. The truth of the Indian rule for R cos S′SQ is easily seen from the spherical triangle πZS, where π is the pole of the ecliptic,

Greek Method :

[3]Ptolemy takes SK and SL=90° each, along the vertical circle ZSEK and the ecliptic N′SA. The great circle through K and L cuts the horizon at R which is the pole of the vertical circle. He takes SKL for the triangle and EAR for the transversal, then

$$\frac{\sin SE}{\sin EK}\times\frac{\sin KR}{\sin LR}\times\frac{\sin LA}{\sin AS}=1$$

or $$\sin LR=\frac{\cos ZS\times\cos AS}{\sin ZS\times\sin AS}$$

or $\cos S'SQ=\cot ZS\times\cot AS=\tan SE\times\cot AS.$

The Indian and the Greek rules are altogether different both in form and method. There can, therefore, be no question of any connection between them.

Problem VIII :—

To convert the Celestial Longitude of a Heavenly Body into its Polar Longitude

If σ be the position of a (Fig.13), ♈K and σK are the celestial longitude and the celestial latitude, respectively ; ♈M and σM′ are the polar longitude and polar latitude ; ♈N and σV are the right ascension and declination of the star.

Indian Method :

All Indian astronomers attempt at finding MK which, sub-

1. Āryabhaṭa, *Gola*, 34; *Pañcasiddhāntikā*, IX, 22 *BrSpSi.* XI. 23.
2. *BrSpSi.* V, 4-5 ; *Sūryasiddhānta*, V, 7-8 Bhāskara, *Grahagaṇita*, XII, 4.
3. Manitius, ibid, p. 119.

tracted from, or added to, γK the celestial longitude, gives γM the polar longitude.

According to Āryabhaṭa[1],

$$MK = \frac{\sigma K \times R \text{ vers } \gamma K \times R \sin \omega}{R^2}.$$

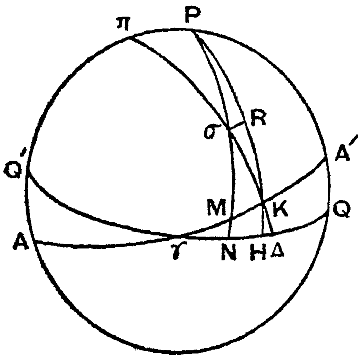


Fig- 13

Brahmagupta[2] makes a distinct improvement on Āryabhaṭa and gives his rule for finding the projection MK on the celestial equator.

If P be the celestial pole, PKH the secondary to the equator, Brahmagupta says that,

$$NH = \frac{\sigma K \times R \sin (\gamma K + 90^\circ) \times R \sin \omega}{R}$$

If from σ, σR is drawn perpendicular to PKH, it is evident that,

$$R \sin \sigma R = \frac{R \sin \sigma K \times R \sin \sigma KR}{R}.$$

According to Āryabhaṭa and Brahmagupta, as explained before,

$$R \sin \sigma KR = \frac{R \sin (\gamma K + 90^\circ) \times R \sin \omega}{R}$$

Hence Brahmagupta intends that,

$$NH = \sigma R = \frac{\sigma K \times R \sin \sigma KR}{R}$$

which is rather a big assumption. He then directs the finding of the part of the ecliptic of which σR or NH is the projection on the equator thus approximately to MK.

Āryabhaṭa, Brahmagupta[3] and the modern *Sūryasiddhānta* take the declination $\sigma N = \sigma K + KH$ where σK is small. They do not consider the case where σK is large.

Bhāskara alone gives us fairly correct rules for this transformation of co-ordinates.

1. Āryabhata, *Gola*, 36.
2. *BrSpSi* X. *17*.
3. *BrSpSi*, X. 15, *Sūryasiddhānta*, II, 58.

In order to find σN, he would multiply

σK by $\frac{\text{R cos } \sigma\text{KP}}{\text{R}}$; according to him,

$$\sigma N = \frac{\sigma K \times R \cos \sigma KP}{R} + KH$$[1]

This is a decided improvement on Brahmagupta's corresponding rule. The declination σN obtained would be very nearly accurate.

Having obtained σN, Bhāskara[2] then directs the finding of NH, thus,

$$NH = \frac{\sigma K \times R \sin \sigma KP}{R \cos \sigma N}$$

He then directs the finding of MK on the ecliptic of which NH is the projection by means of the times of rising of the signs of the zodiac on the equator.

Thus, the Indian methods show a beginning and development only. The Greek method as given by Ptolemy is mathematically accurate.

Greek Method[3]

To transform the celestial longitude and celestial latitude to right ascension and declination.

Let the great circle $\pi\sigma$K meet the equator at Δ. Ptolemy would then from the given value of γK, find $\gamma\Delta$ and ΔK by using his tables for the rising of signs of the zodiac on the equator. He then takes πPσ for the triangle and γNΔ Q for the transversal. The Menelaus' Equation, then, is

$$\frac{\sin \pi Q}{\sin QP} \times \frac{\sin PN}{\sin N\sigma} \times \frac{\sin \sigma\Delta}{\sin \Delta\pi} = 1^2$$

Here $\pi Q = 90° + \omega$, $QP = 90°$, $PN = 90°$; $\sigma\Delta = \sigma K + K\Delta$.
$\pi\Delta = 90° + K\Delta$, whence $N\sigma$ is obtained.

He next takes PNQ for the triangle and $\pi\sigma\Delta$ for the transversal,

$$\therefore \frac{\sin P\pi}{\sin \pi Q} \times \frac{\sin Q\Delta}{\sin \Delta N} \times \frac{\sin N\sigma}{\sin \sigma P} = 1$$

Here $P\pi = \omega$, $\pi Q = 90° + \omega$, $Q\Delta = 90° - \gamma\Delta$.

Hence the above equation gives him ΔN. Now,
$\gamma N = \gamma\Delta - \Delta N$,

1. Bhāskara, *Grahagaṇita* XIII, 3.
2. Ibid. XIII, 4.
3. Manitius, Ibid, Vol, II. *Achtes Buch*, pp. 84-85.

It is almost needless to say that neither in the method nor in the rules is there any agreement between the Indian and Greek spherical astronomy in the solution of this problem.

Kaye's view[1]

As to Kaye, it appears that he has not been able to find a method in the translation of the *Sūyrasiddhānta* by Burgess. The figures of his paper referred to before do not show the "*Akṣakṣetras*" even in their projections on the meridian place. He refers to Braunmühl's *History of Trigonometry* but does not appear to have been able to follow him in his "*Methode der indischen Trigonometrie.*" Kaye, however, is not slow in belittling Indian trigonometry when he says :—The Indian astronomers employed the sine function principally and the versed sine occasionally ; they never employed the tangent function; and generally, but not always, preferred to employ the sine of the complementary angle rather than the cosine functions.''

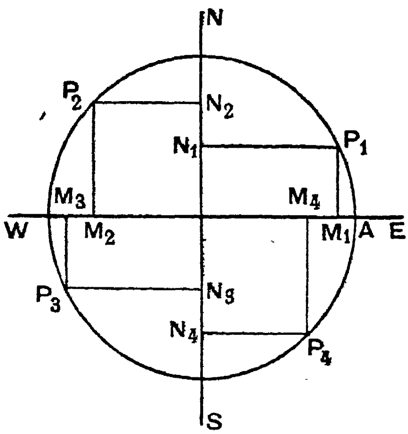


Fig. 14

It is evident that Kaye never understood the meaning of the Indian functions of 'sine' and 'cosine.' These functions are fully explained by Bhāskara[2] when he says :—

"Of that point the distance from the east-west line is the sine and the distance of the point from the north-south line is the "cosine".

In (Fig. 14), of the arc AP_1, P_1M_1 is the "sine" and P_1N_1 is the "cosine" of AP_2, P_2M_2 is the "sine" and P_2N_2 is the "cosine"; of AP_3, P_3M_3 is the "sine" and P_3N_3 is the "cosine"; etc. It is evident that a better definition of these functions was never given.

We have thus seen that some of the solutions of Āryabhaṭa

1. J. A. S. B., N. S., XV, p. 154.

2. तस्य बिन्दोः प्राच्य-परायाश्च यदन्तरं सा दोर्ज्या ।
बिन्दोर्याम्योत्तरायाश्च यदन्तरं सा कोटिज्या ॥
—(Bhāskara, *Grahagaṇita*, commentary. II, 88-21

are imperfect, of Brahmagupta the solutions are more accurate, while those of Bhāskara are generally mathematically correct. The date of the scientific ancient Indian Astronomy is indeed 499 A. D., while that of the Syntaxis is about 150 A. D. It is by these shortcomings and differences in the methods, new ideas (e.g., the idea of the differential calculus)* and the like, that we can safely say that Indian Astronomy in its scientific form, although of a later date than the "Syntaxis" of Ptolemy, is original and not borrowed from foreign source. There is evidence that some crude form of Greek astronomy was transmitted to India and went by the name of the "*Romaka*" or the "*Pauliśa*" Siddhānta, prior to the time of Āryabhaṭa but our great Indian astronomers, Āryabhaṭa with his pupils, Varāha-mihira and Brahmagupta, had to construct a new science altogether.

(This Chapter is almost a reproduction of the paper by P. C. Sengupta, as acknowledged earlier).

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Reference

P.C. Sengupta : The *Khaṇḍakhādyaka*, 1934

CHAPTER VII

Epicyclic Theory of Ancient Indians

We shall give here some details of the Indian concepts regarding the motion of planets or wandering bodies among the stars. The *Vedāṅga Jyotiṣa* (1400 B. C. or earlier) does not speak of this, A comparison of the astronomical constants of the Greek and the ancient Indian systems, points unmistakably to the conclusion that the Indian constants as determined by Āryabhaṭa I and his successors, are almost in all cases different from those of Greeks. Indian astronomers were highly original in their concepts and treatment. The originality of Āryabhaṭa I and other astronomers would be seen from what we are discribing below.

Apparent Motions of the Sun and Moon

We have the following passages from Āryabhaṭa :

All planets move in eccentrics to their orbits at the mean rates of angular motion, in the direction of the signs of the zodiac from their apogees (or aphelia) and in the opposite directions from their *Śighroccas.*

The eccentric circles of planets are equal to their concentrics and the centre of the eccentric is removed from the centre of the Earth.

The distance between the centre of the Earth and the centre of the eccentric is equal to the radius of the planet's epicycle; on the circumference (whether of the epicycle or of the eccentric) the planet undoubtedly moves with the mean motion.

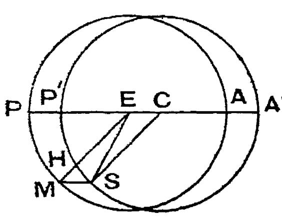


Fig. 15

Here the central idea was that undoubtedly planets moved unifomly in circles round the Earth; if the motion appeared to be variable, it was due to the fact that the centres of such circle (i. e. the concentric circles) did not coincide with the centre of the Earth.

Let E represent the centre of the Earth(Fig.15), APM the Sun's circular orbit or concentric; let A and P be the apogee and the perigee respectively. From EA, cut off EC equal to the radius of the Sun's epicycle. With centre C and radius equal to EA describe the eccentric A'P'S cutting AP and AP produced at P' and A'. Here A' and P' are the real apogee and perigee of the Sun's orbit. Let PM and P'S be any two equal arcs measured from P and P.'

The idea is that the mean planet M and the apparent Sun S move simultaneously from P and P' in the counterclockwise direction along the concentric and the eccentric circles. They move with the same angular motion and arrive simultaneously at M and S.

Here EM and CS are parallel and equal, hence MS is also equal and parallel to EC. Let SH be drawn perpendicular to EM.

The angle PEM is the mean anomaly and the angle P'ES the true anomaly; the angle SEM is the equation of the centre, is readily seen to be plus (+) from P' to A' and minus (−) from A' to P'. Thus as regards the character of the equation, the eccentric circle is quite right. We now turn to exmine how far it is true as to the amount.

Let the angle SEM denoted by E and the angle $\angle$PEM $=\angle$P'CS$=\theta$; EP=CP'$=a$; EC=MS$=p$, then

$$\tan E=\frac{SH}{HE}=\frac{p\sin\theta}{a-p\cos\theta}$$

$$\therefore \qquad E=\frac{p}{a}\sin\theta-\frac{p^2}{2a^2}\sin 2\theta+\frac{p^3}{3a^3}\sin 3\theta\ldots\ldots\ldots$$

Now the true value of E in elliptic motion is given by

$$E=\left(2e-\frac{e^3}{4}\right)\sin\theta+\frac{5}{4}e^2\sin 2\theta+\frac{13e^3}{12}\sin 3\theta^*;\ldots$$

It we now put $\frac{p}{a}=2e-\frac{e^3}{4}$, as a first appoximation $\frac{p}{a}=2e$.

Hence $\frac{p^2}{2a^2}=2e^2$, which is greater than $\frac{5}{4}e^2$ by $\frac{3}{4}e^2$. In the case of the Sun if the value of p be correctly taken the error in the coefficient of the second term becomes+3'; similarly in the case of the Moon, the corresponding error becomes+8'.

*Godfray's *Astronomy*, p. 149.

Again if $\frac{p}{a}=2e$, what is the centre of the eccentric circle is the empty focus of the ellipse or that the ancient astronomers practically took the planets to be moving with uniform angular motion round the empty focus. This was not a bad approximation.

Also ES=r=EH approximately,

$$\therefore \quad r=a\left(1-\frac{p}{a}\cos\theta\right)$$

but in the elliptic motion

$$r=a\,(1-e\cos\theta).^*$$

Hence the error is not very considerable here also.

This is the way in which the ancient astronomers, both Greek and Hindu, sought to explain the inequalities in the motion of the Sun and the Moon. In the case of the Moon, these astronomers took the coefficient $2e-\frac{e^3}{4}=300'$ nearly; the modern value is 377′ nearly. The reason for this has been pointed out to be that the Moon was observed correctly only at times of eclipses. At the eclipses of sygygies, the evection term of the Moon's equation diminishes (numerically) the principal ecliptic term by about 76′.

We have thus far explained the idea of planetary motion of the ancients under the eccentric circle costruction. The same, however, is explained under the epicyclic construction.

Let AMP be the circular orbit of the Sun, having E the centre of the earth for the centre. (Fig. 16) Let the diameter AEP be the apse line. A the apogee and P the perigee. Let M be the mean position of the Sun in the orbit. With M as the centre, describe the epicycle UNS. Let EM cut the epicycle at N and U. Now the construction for finding S the apparent Sun is thus given:—

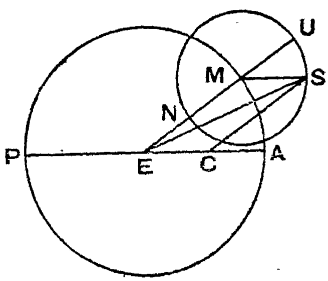


Fig. 16

Make ∠UMS=∠MEA, the arc US is measured clockwise whereas the arc A to M is measured counterclockwise.

From this construction MS is parallel to EA. If EC be measured equal to MS, the radius of the epicycle, along EA to-

* Godfray's *Astronomy*, p. 149.

wards the apogee, then CS is a constant length and C is a fixed point. Hence the locus of S is an equal circle with the centre at C. Thus both the eccentric, and the epicycle and the concentric combined, led to the same position.

It was thus usual to explain the planetary motion under both the assumed constructions; and both gave the position for a planet. The eccentric circle construction appears to be the earlier in the history of astronomy and the latter was later. If the former construction can be traced to Apollonius of Perga who did so much to develop the "conic sections" as science, the reason why he preferred the eccentric circle to the ellipse, appears to be that either that this planetary construction was always deep-rooted in the minds of men or that he was carried by the idea that "the circle was the most perfect curve." We are inclined to the view that the eccentric circle idea was transmitted from Babylonia to Greece. We now pass on to consider the Indian construction for the possition of superior and inferior planets.

Superior Planets

With regard to the five planets, Mercury, Venus, Mars, Jupiter and Saturn, the Indian astronomers give only one construction for finding the apparent geocentric position. Each of these "star planets" is conceived as having twofold planetary inequalities : (i) the inequality of apsis, (ii) the inequality of the *śighra*. With regard to the superior planets, the *śighra* apogee or the *śighrocca* coincided with the mean position of the Sun. As Varāhamihira observed, of the other planets beginning with Mars, the Sun is the so-called *śighra*. (*PSi*. XVII. 1)

Let AMSP be the concentric of which the centre E is the same as that of the earth(Fig.17); $A'M_1P'$ the eccentric circle of apsis of a superior planet, of which the centre is C;A,M,S,P be respectively the apogee, the Mars planet, the direction of the *śighra* and the perigee of the concentric; A', M_1, P' be the apogee, the planet as corrected by the equation of apsis, P′ the perigee in the eccentric. The arc

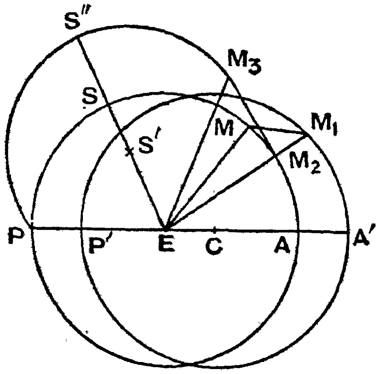


Fig. 17

AM=arc $A'M_1$; MM_1 is parallel and equal to EC. As used before, both the concentric and the eccentric are of the same radius.

Here the mean planet M in the concentric is taken to be deflected to M_1 due to the true motion in the eccentric circle. Join EM_1 cutting the concentric at M_2. Now let ES be joined and let S′ be taken along ES, such that

$$\frac{ES'}{ES}=\frac{\text{Śighra periphery of the planet in degrees}}{360}$$

$$=\frac{\text{Sun's mean distance from the Earth}}{\text{Planets mean distance from the Sun or the Earth;}}$$

ES′ thus determined is called the radius of the *śighra* epicycle of the superior planet.

With S′ as the centre and the radius equal to ES or EA describe another circle which is called the *śighra* eccentric cutting ES produced at S″. Now measure the arc $S''M_3$ in the concentric=SM_2 in the concentric. The apparent superior planet is seen in the direction EM_3 from the Earth. This is the construction used in Hindu astronomy calculating the geocentric longitude of any star planet.

It is evident in the case of a superior planet that the eccentric having S′ for the centre and whose radius=EA=R the standard radius for any circular orbit, is the mean orbit of the planet and S′ the mean position of the Sun. In other words, in the case of a superior planet, the *śighra* eccentric represents the mean orbit round the Sun. If the parallelogram CES′C′ be constructed, then an equal circle described with C′ as the centre is the apparent eccentric orbit of the superior planet.

In the actual method of calculating the geocentric longitude of a "star planet" there are four operations given, the first two of which have the effect of changing the arc MA or rather the point A. The last two operations relate to the two displacements MM_1 and M_2M_3. We have here followed solely the construction of the eccentric circles; the same geocentric position of a superior planet could be equally well obtained by the epicyclic construction. In describing the constructions for finding the position of an inferior planet we shall follow the epicyclic construction only

Inferior Planets

Let E be the centre of the Earth (Fig. 18), AMS the orbit of

a mean inferior planet or the mean Sun. EA the direction of the apogee of apsis and ES that of the *śighra*. The inequality of the apsis takes the mean geocentric planet from M to M_1, such that MM_1 is parallel to EA. Let EM_1 be joined cutting the concentric at M_2 ; M_2 is taken as the centre of the *śighra* epicyle or the real circular orbit in which the apparent planet moves.

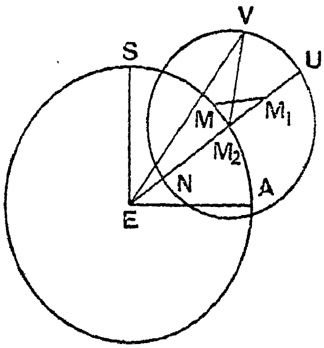


Fig. 18

With M_2 as the centre and the radius of the inferior planents' *śighra* epicycle as radius, describe the circle NVU which is here the *śighra* epicycle or the real circular orbit. In it draw the radius M_2V parallel to ES; then VP is the geocentric position of the inferior planet.

Here the first displacement MM_1 is due to the inequality of apsis and is for finding the position of M_2 the centre of the real circular orbit. The idea was that the apparent planet moved in a circular orbit of which the centre was very near the mean position of the Sun, the first operation in this construction was calculated to determine the centre of this so-called circular orbit of an inferior planet.

The *śighra* of an inferior planet moves round the Earth at the same mean rate in which the inferior planet moves round the Sun; hence the line ES in this figure is always parallel to the line joining the Sun to the mean heliocentric inferior planet, and in our construction, it is parallel to M_2V.

This in brief is an outline of the Indian idea of planetary motion as taught by Āryabhaṭa I, Brahmagupta and Bhāskara II.

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Reference

P.C. Sengupta : The *Khaṇḍakhādyaka*, 1934.

CHAPTER VIII

Brahmagupta and Arithmetic

Scope of Gaṇita

The word *Gaṇita* means the science of calculation. The term occurs in the *Vedāṅga Jyautiṣa* (c. 1200 B. C.) :

> Just as the crest is to the peacocks, and just as the head-gem is to the snakes, so the Gaṇita among the Vedāṅga Śāstras stands at the head.[1] (VJ. 4)

In the ancient Buddhistic literature, we find mention of three classes of *gaṇita* : (i) *mudrā* (finger arithmetic). (ii) *gaṇanā* (mental arithmetic), and (iii) *saṁkhyāna* (higher arithmetic in general). In the *Brāhmasphuṭasiddhānta*, Brahmagupta uses the word *gaṇita* in the sense of entire calculations. His *gaṇitādhyāya* (Chapter XII) includes ;

> (i) *Miśraka* (mixtures). (ii) *Śreḍhī* (series). (iii) *Kṣetra* plane figures), (iv) *Vṛtta-kṣetra* (circles), (v) *Khāta* (excavations), (vi) *Citi* (piles of bricks), (vii) *Krākacika* (sawn pieces of timber), (viii) *Rāśi* (heaps or mounds of grain, and (ix) *Chāyā* (shadow).

Brahmagupta also uses the term *Dhūlikarma* (literally meaning "dustwork") for higher mathematics :

> The one learned man who knows the *dhūlikarma* or the science of mathematics as propounded by Brahmagupta would far excell them in learning who are taught the calculations according to Āryabhaṭa. Viṣṇucandra and others.[2]

> In these ten chapters of the *Brahmasiddhānta* has been given the *dhūlikarma* or the science of entire calculations

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1. यथा शिखा मयूराणां नागानां मणयो यथा ।
तद् वद् वेदांग-शास्त्राणां गणितं मूर्धनि स्थितम् ॥ *VJ. 4.*

2. नावार्यो ज्ञातेरपि तन्त्रैरार्यभटविष्णुचन्द्राद्यैः ।
यो ब्रह्म धूलिकर्मविदाचार्यत्वं भवति तस्य ॥ —*BrSpSi. X. 62.*

> which is faultless.[1]
>
> This science of *dhūlikarma* has not been imparted by great teachers for blasphemy. One who would be using it tor this purpose would lose all good name.[2]

Brahmagupta uses the term *gaṇita* only for those calculations which are of arithmetical in nature. The science of algebra, the foundations of which was laid by Āryabhaṭa I, was named as *kuṭṭaka* or *kuṭṭākāra* by Āryabhaṭa, and in the *Brāhmasphuṭa-siddhānta* also it is separately dealt with under *Kuṭṭādhyāya* or *kuṭṭakādhāya* (Chapter XVIII). Later on the term *bījagaṇita* was specifically given to the science of algebra.

The *Kuṭṭādhyāya* of the *Brāhmasphuṭasiddhānta* deals with the (i) concept of *kuṭṭaka* (pulveriser), addition of positive and negative as well as zero quantities, equations in one unknown (*eka-varṇa samīkaraṇa*), equations in several unknowns (*aneka-varṇa samīkaraṇa*), equations involving products of unknowns (*bhāvita*) and quadratic equations (*varga-prakṛtiḥ*) (Chapter XVIII of the *Brāhmasphuṭasiddhānta*).

Āryabhaṭa, Bhāskara and Brahmagupta use Place Value Notations.

In Europe the first definite traces of the place-value numerals are found in the tenth and eleventh centuries, but the numerals came into general use in mathematical text books only in the seventeenth century. In India, however, Āryabhaṭa I (499), Bhāskara I (522), Lalla (c. 598) and Brahmagupta (628) all use the place value numerals. There is no trace of any other system in their works. Perhaps in this country we had the place value system as early as 200 B.C. if not earlier. The use of a symbol for zero is found in Piṅgala's *Chandaḥ Sūtra* (perhaps of 200 B.C.). In literature, we have an indication of the place value from about 100 B.C. and later in the Purāṇas from the second to the fourth century A.D. The *Bakhaśālī Manuscript* (perhaps of 200 A.D.) uses the place-value notations. The earliest use of the place value principle with the letter numerals

1. ग्रहयोगोत्र ग्रहयुतिरार्यात्रिंशतियुताष्टसप्तत्या ।
अध्यायैर्दशभिर्धूलिकर्म वोच्चेर्विना ब्रह्मै ॥ —*BrSpSi*. X. 66.

2. गुरुणा न धूलिकर्म प्रतिकंचुककारिणे प्रदातव्यम् ।
दत्त सुकृतप्रणाशं कुरुते प्रतिकंचुकं यस्य ॥ —*BrSpSi*. X. 67

is found in the works of Bhāskara I about the beginning of the sixth century A.D. Thus for 3179, the expressive words are *Navādrirūpāgni*[1] (*nava* 9, *adri* 7. *rupa* 1 and *agni* 3). Similarly in the *Brāhmasphuṭasiddhānta*, for a large number like 2296828522, the expressive terms are DVIYAMAŚARĀṢṬAPAKṢAVASŪRA-SANAVADVIYAMĀḤ(*Dviyama* two twos 22, *Śara* 5, aṣṭa 8, *pakṣa* 2, *vasū* 8, *rasa* 6. *nava* 9, *dviyamāḥ* 22).[2] Such usages are to be found in all works, which clearly state the place value concept was popular as a routine. From India, this system reached Arabia. During the reign of the Khalif Al-Mansur (753-774 A.D.) there came embassies from Sindh to Baghdad, and among them were scholars, who brought along with them several works on mathematics including the *Brāhmasphuṭasiddhānta* and the *Khaṇḍakhādyaka* of Brahmagupta: With the help of these scholars, Al-fazari, perhaps also Yakub ibn Tarik, translated them into Arabic. Both works were largely used and exercised great influence on Arab mathematics. It was on that occasion that the Arabs first became acquainted with a scientific system of astronomy. It is acceptable to all writers on the subject that it was at that time that the Hindu numerals were first definitely introduced amongst the Arabs. Arabs at first adopted the *ghobar* form of numerals which they had already obtained (but without zero) from the Alexandrians or from the Syrians. This they continued for about two centuries, but since they were not suited to their right-to-left script, they gave them up and adopted the more convenient ones. For a detailed discussion on how numerals went to the west from India and spread in Europe one is referred to this discussion in the *History of Hindu Mathematics.* Part I by Datta and Singh (1935, Single volume Edition, 1962, pp. 83-104). It is remarkable that Brahmagupta's works like the *Brāhmasphuṭasidhānta* and the *Khaṇḍakhādyaka* became instrumental in the spread of the place-value notation in the neighbouring countries of the Middle East, and from their this system spread into Europe.

Operations and Determinations in Pāṭīgaṇita

The word *Pāṭīgaṇita* is a compound formed from the words *pāṭī*, meaning 'board', and *gaṇita*, meaning 'science of calculation',

1. *MBh. 1. 4;*
2. *BrSpSi 1-16.*

hence it means the science of calculation which requires the uses of writing material (the board). The word *pūṭi* is not Sanskrit (it originated in the non-Sanskrit literature in India); the oldest term in Sanskrit for the board is *Phalaka* or *paṭṭa*. However this term got currency in the Sanskrit literature also about the beginning of the seventh century. Brahmagupta does not use the term *pāṭīgaṇita*: he favours the use of the term *dhūlikarma* or writing figures on dust spread on a board or on the ground. The word *pāṭīgaṇita* was translated into Arabic as *ilm-hisab-al-takht* (calculation on board) and the word *dhūlikarm a* as *hisab-al-ghobār* (calculation on dust).

Brahmagupta, in the very first verse in the Chapter XII (*Gaṇitādhyāya*) refers to twenty operations (*parikarma*) and eight determinations :

> He who distinctly and severally knows the twenty logistics, addition etc.. and the eight determinations (*vyavahāra*) inculding (measurement by) shadow is a *gaṇaka* (mathematician).[1]

The commentators have given the list of these logistics (*parikarma*) and determinations (*vyavahāra*) as follows;

(A) *Parikarma* or logistics

1. Saṁkalitam (addition)
2. Vyavakalitam (subtraction)
3. Gaṇanam (multiplication)
4. Bhāgahāraḥ (division)
5. Vargaḥ (square)
6. Vargamūlam (square-root)
7. Ghanaḥ (cube)
8. Ghanamūlam (cube root)
9. 13. Five standard forms of fractions (Pañca-jāti)
14. Trairāśikam (the rule of three)
15. Vysta-trairāśikam (the inverse rule of three)
16. Pañca-rāśikam (the rule of five)
17. Sapta-rāśikam (the rule of seven)
18. Nava-rāśikam (the rule of n ine)

---

1. परिकर्म विंशतिं यः संकलिताद्यां पृथक् विजानाति ।
अष्टौ च व्यवहारान् छायान्तान् भवति गणकः सः ॥ —*BrSpSi*. *XII*. *1*

19. Ekādaśa-rāśikam (the rule of eleven)
20. Bhāṇḍa-pratibhāṇḍam (barter and exchange)

(B) *Vyavahāra* or determinations

1. Miśrakaḥ (mixture)
2. Śreḍhī (progession or series)
3. Kṣetram (plane figures)
4. Khātam (excavation)
5. Citiḥ (stock)
6. Krākacikaḥ (saw)
7. Rāśiḥ (mound)
8. Chāyā (shadow)

Of the operations enlisted here, the first eight have been considered fundamental by later writers as Mahāvīra. The operations of duplation and mediation (doubling and halving) were considered fundamental by Arabs, Greeks and Egyptians; since they were not familiar with the place-value system.

Mathematics in this country developed as an aid to astronomy, and therefore, for the first time we find Āryabhṭa(499AD.) in his *Āryabhaṭīya* describing as a special section (*Gaṇitapāda*). Brahmagupta (628 A.D.) also followed Āryabhaṭa in this respect and gave the science of calculation (*gaṇita*) a special place in his treatise on astronomy. The *Siddhānta* treatises, earlier than those of Āryabhaṭa and Brahmagupta do not contain a chapter exclusively devoted to *gaṇita* (the *Sūrya-Siddhānta* and the Siddhāntas of *Vasiṣṭha*,*Pitāmaha* and *Romaka* are thus without *gaṇita* chapetrs). Later on Bhāskara I and Lalla also did not include *gaṇita* as a section or chapter in their treatises.It is said, however, that Lalla wrote a separate treatise on *Pāṭīgaṇita*.

It may further be remarked here that Āryabhaṭa I gives the rules for finding the square and cube-roots only whilst Brahmagupta gives the cube-root rule only (*BrSpSi*. XII. 7).

Multiplication

Undoubtedly the common Indian name 'multiplication' is '*guṇana*', this term occurs in the Vedic literature also. The other terms for this logistics are *hanana*, *vadha*, *kṣaya* etc., which all mean 'killing' or 'destroying.' The synonyms of '*hanana*' (killing) for multiplication have been used by Āryabhaṭa I (499). Brahmagupta (628), Śrīdhara (c.750) and later writers, and these terms

also occur in the Bakhaśālī Manuscript.

Āryabhaṭa I does not mention the everyday methods of multiplication in his *Āryabhaṭīya* probably because they were too elementary to be included in a Siddhānta work. Brahmagupta, however, in a supplement to the section on mathematics in his *Siddhānta*, gives the names of some methods with very brief descriptions of the processes:—

> The multiplicand repeated, as in *gomūtrikā* as often as there are digits in the multiplier, is severally multiplied by them and (the results) added according to places; this gives the product. Or the multiplicand is repeated as many times as there are component parts in the multiplier.[1]

(the word *bheda* occurring in the verse has been translated as "integrant portions" by Colebrooke p. 319. Again by the term *bheda* are meant portions which added together make the whole, or aliquot parts which multiplied together make the entire quantity.

> The multiplicand is multiplied by the sum or the difference of the multiplier and an assumed quantity and, from the result the product of the assumed quantity and the multiplicand is subtracted or added.[2]

(Colebrooke thinks that this is a method to obtain the true product when the multiplier has been taken to be too great or too small by mistake.[3] Datta and Singh think, however, that this is not correct.[4]

Thus Brahmagupta mentions four methods of multiplication: (i) *gomūtrikā*, (ii) *khaṇḍa*. (iii) *bheda*, and (iv) *iṣṭa*. The common and the well known method of *kapāṭa-sandhi* has been omitted by him.

---

1. गुणकारखण्डतुल्यो गुण्यौ गोमूत्रिकाकृतो गुणितः ।
सहितः प्रत्युत्पन्नो गुणकारकभेदतुल्यो वा ॥ —*BrSpSi XII. 55*

2. गुण्यो राशिगुणकारराशिनेष्टाधिकोनकेन गुणः ।
गुण्योष्टवधो न युतो गुणकेऽभ्यधिकोनके कार्यः ॥ —*BrSpSi. XII. 56*

3. Colebrooke, T. H., *Hindu Algebra*, p. 320.

4. Datta, B. and Singh, A. N., *History of Hindu Mathematics* Pt. I (Arithmetic), p. 135 (1962).

(i) *Gomūtrika*-method or zig-zag method. The word *gomūtrikā* means "similar to the course of cow's urine", hence "zigzag". This method in all essentials is the same as the *sthāna-khaṇḍa* method. The following illustration is based on the commentary of Pṛthūdaka Svāmī :

Example : To multiply 1223 by 235.

The numbers are written thus :

```
2   1223
3    1223
5     1223
```

The first line of figures is then multiplied by 2, the process beginning at units place, thus : $2 \times 3 = 6$; 3 is rubbed out and 6 substituted in its place, and so on. After all the horizontal lines have been multiplied by the corresponding numbers on the left in the vertical line, the numbers on the *pāṭī* stand thus :

```
2446
 3669
  6115
------
287405
```

after being added together as in the present method.

The *sthāna-khaṇḍa* and the *gomūtrikā* methods resemble modern plan of multiplication most closely.

(ii) *Khaṇḍa* Method or Parts Multiplicatian Method : Since the days of Brahmagupta, this method of multiplication also became very popular. We have two methods under this head :

(i) The multiplier is broken up into two or more parts whose sum is equal to it. The multiplicand is then multiplied severally by these and the results added.

To take an example :

$$13 \times 158 = (6+7) \times 158 = (6 \times 158) + (7 \times 158)$$
$$= 948 + 1106$$
$$= 2054$$

(ii) The multiplier is broken up into two more aliquot parts. The multiplicand is then multiplied by one of these, the resulting product by the second and so on till all the parts are exhausted. The ultimate product is the result.

Thus for example :

$$96\times237=(4\times4\times6)\times237$$
$$=(4\times237)\times4\times6=948\times4\times6$$
$$=(4\times948)\times6=3792\times6$$
$$=22752$$

These methods of multiplication are found among the Arabs and the Italians, having obtained from people of India. They were known as the "Scapezzo" and "Repiego" methods respectively amongst Italians.

(iii) *Iṣṭa-guṇana* Method or the Algebraic Method.

We have already quoted the relevant verse from the *Brāhmasphuṭa-siddhānta* in this connection; (XII. 56) :

> The multiplicand is multiplied by the sum or the difference of the multiplied and an assumed quantity and from the result the product of the assvmed quantity and the multiplicand is subtracted or added.[1]

This method is of two kinds according as we (i) add or (b) subtract an assumed number. The assumed number is so chosen as to give two numbers with which multiplication will be easier than with the original multiplier. The two ways are illustrated below :

(i) $93\times13=(93+7)\times13-7\times13=1300-91=1209.$

(ii) $93\times13=(90+3)13=90\times13+3\times13=1170+39$
$=1209$

This method was in use among the Arabs and in Europe, obviously having gone out from this country.

This process has been regarded as an inverse of multiplication. The terms used for this operation are *bhāgahāra*, *bhājana*, *haraṇa*, *chedana*, etc., all these terms more or less carrying the sense "to break into parts", "to divide" etc., excepting "*haraṇa*" which denotes "to take away". This term shows the relation of division to the operation of subtraction. The dividend is termed as *bhājya*. *hārya* etc., the divisor is known as

1. गुरयो राशिगुणकारराशिनेष्टाधिकोनकेन गुणः ।
गुण्येष्टवधो न युतो गुणकेऽभ्यधिकोनके कार्यः ।। —*BrSpSi. XII. 56*

bhājaka, *bhāgahāra* or simply *hara*; quotient is known as *labdhi* or *labdha* (or "what is obtained").

India never regarded this operation as a difficult one; in Europe, this operation was regarded as a tedious one till the 15th century or so. Division was such a common operation that Āryabhaṭa did not regard it as worth being included in his treatise. But since he has given the methods of extracting square-roots and cube-roots, which obviously depend on division, we conclude that the method of division was known to him. Most *Siddhānta* writers have followed Āryabhaṭa I in omitting this operation from their texts, this being regarded too elemantary to be included. Brahmagupta does not give details of this operation. The later treatises on Arithmetic as Śrīdhara's *Triśatikā* and the *Pāṭīgaṇita* (I.20) and Āryabhaṭa II (c.950 A.D.) have given the details of this operation.

Square

The Sanakrit term for square is *varga* or *kṛti* (*varga* literally means "rows" or "troops" of similar things). In mathematics, it usually means the square power and also the square figure or its area. Thus we find in the *Āryabhaṭīya* :

> A square figure of four equal sides (and the number representing its area) are called *varga*. The product of the two equal quantities is also *varga*[1].

The term *kṛti* means "doing", "making" or "action". It carries with it the idea of specific performance probably the graphical representation.

For the first time we have a definite rule for squaring in the writings of Brahmagupta. But it does not mean that prior to him it was not known. It must have been known to Āryabhaṭa I since he has given the square-root method.

Brahmagupta gives his method of squaring briefly as follows :

> Combining the product, twice the digit in the less (lowest) place into the several others (digits) with its (i.e. of the digit in the lowest place) square (repeatedly) gives the square.[2]

---

1. वर्गस्समचतुरश्रः फलञ्च सदृशद्वयस्य संवर्गः । —*Ārya. II.* 3.

2. राशेरूनं द्विगुणं बहुतरगुणमूनकृतियुतं वर्गः । —*BrSpSi. XII.* 63.

The method has been more clearly enunciated by Mahāvīra (850 A.D.) in the *Gaṇitasārasaṁgraha* :

> Having squared the last (digit), multiply the rest by the digits by twice the last, (which) is moved forward (by one place). Then moving the remaining digits continue the same operation (process), This gives the square.[1]

Brahmagupta's method of squaring is shown by the following example :

To square 125.

The number is written down

125

The square of the digit in the last place, i. e., $5^2=25$ is set over it thus :

25
125

Then, $2 \times 5=10$ is placed below the other digits, and 5 is rubbed out, thus :

25
12
10

Multiplying by 10 the rest of the digits, i.e., 12 and setting the product over them (the digits), we have.

1225
12
10

Then rubbing out 10 which is not required and moving the rest of the digits, i. e. 12 we, have

1225
12

Thus one round of operations is completed.

Again as before, setting the square of 2 above it and $2\times2=4$ below 1. we have

1625
1
4

1. GSS. P. 12.

Multiplying the remaining digit 1 by 4, and setting the product above it, we have

5625
1

Then moving the remaining digit 1, we obtain

5625
1

Thus the second round of operations is completed.

Next setting the square of 1 above it the process is completed for there are no remaining figures, and the result stands thus :

15625

Algebraic Method of Squaring

Brahmagupta in his *Brāhmasphuṭasiddhānta* gives a minor method of squaring thus :

> The product of the sum and the difference of the number (to be squared) and an assumed number plus the square of the assumed number give square[1].

This may be represented by the following identity :

$$n^2=(n-a)\ (n+a)+a^2$$

This identity has been used for squaring by most of the Indian mathematicians. Thus

$$15^2=(15-5)\ (15+5)+5^2=225$$

We are not giving here other identities which have been used by latter mathematicians of India in getting the squares of numbers; for example, when Mahāvīra says :

> The sum of the squares of the two or more portions of the number together with their products each with the others multiplied by two gives the square[2] :

he obviously refers to the identity

$$(a+b+c\ldots\ldots\ldots\ldots)^2=a^2+b^2+c^2+\ldots\ldots+2ab+\ldots\ldots$$

Cube

The Sanskrit term for cube is *ghana*. It when used in the geometrical sense also means the solid cube. In the arithmetical sense, it means the continued product of the same number taken three times. Thus we have the definition in the *Ārya-*

1. राशेरिष्टयुतोनाद्वधः कृतिर्वेष्टकृतियुक्तः । — *BrSpSi. XII. 63*
2. *GSS*. p. 13.

bhaṭīya :

> The continued product of three equals and also the solid having twelve (equal) edges are called *ghana*.[1]

A method of cubing applicable to numbers written in the decimal place-value notation, has been in use in this country from before the 5th century A.D. Āryabhaṭa I (499 A.D.) had the familiarity with this method; he, however, does not give the method of cubing in his treatise, though he describes the inverse process of extracting the cube-root.

Brahmagupta gives the method of cubing in the following verse :

> Set down the cube of the last (*antya*); then place at the next place from it, thrice the square of the last multiplied by the succeeding; then place at the next place thrice the square of the succeeding multiplied by the last, and (at the next place) the cube of the succeeding. This gives the cube.[2]

The rule may be illustrated by an example.

Example : To cube 1357.

The given number has four places, i.e., four portions. First we take the last digit 1 and the succeeding digit 3, i.e. 13 and apply the method of cubing thus :

(i) Cube of the last (1^3)	=	1
(ii) Thrice the square of the last (3.1^2) multiplied by the succeeding (3) gives ($3.3.1^2$)	=	9 (placing at the next place)
(iii) Thrice the square of the succeeding, multiplied by the last gives ($3.3^2.1$)	=	27 (placing at the next place)
(iv) Cube of the succeeding (3^3)	=	27 (placing at the next place)
Thus 13^3 is the sum		2197

1. सदृशत्रयसंवर्गो घनस्तथा द्वादशाश्रस्यात् ॥ —*Ārya*, *II*. 3.

2. स्थाप्योऽन्त्यघनोऽन्त्यकृतिस्त्रिगुणोत्तरसंगुणा च तत्प्रथमान् ।
उत्तरकृतिरन्त्यगुणा त्रिगुणा चोत्तर घनश्च घनः । —*BrSpSi*. *XII*, 6.

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After this we take the next figure, 5, i.e., the number 135, and in this consider 13 as the last and 5 as the succeeding. Then the method proceeds thus :

(i) The cube of the last (13^3) as already obtained = 2197

(ii) Thrice the square of the last multiplied by the succeeding, i.e. $3.13^2.5$ = 2535 (placing at the next place)

(iii) Thrice the square of the succeeding multiplied by the last, i.e, $3.5^2.13$ = 975 (placing at the next place)

(iv) Cube of the succeeding, i.e. 5^3 = 125 (placing at the next place)

Thus 135^3 is the sum 2460375

Now the remaining figure 7 is taken, so that the number is 1357, of which 135 is the last and 7 the succeeding. The method proceeds thus :

(i) Cube of the last, i.e. (135^3) as already obtained = 2460375

(ii) Thrice the square of the last into the succeeding, i.e, $3. (135)^2. 7$ = 382725 (placing at the next place)

(iii) Thrice the square of the succeeding into the last, i.e. $3.7^2. 135$ = 19845 (placing at the next place)

(iv) Cube of the succeeding i.e. 7^3 = 343 (placing at the next place)

Thus $(1357)^3$ is the sum 2498846293

Evidently these methods of cubing are based on the identity:

$$(a+b)^3=a^3+3a^2b+3ab^2+b^3$$

and keeping in mind the place values of numerals in a given

number (this accounts for keeping the results of each of the four operations at the next place).

Square-Root

Indian synonyms for square-root are *vargamūla* or *pada* of a *kṛti*. The word *mūla* means the "root" of a tree, which may also mean the "foot" or the lowest part or bottom of a thing and hence "pada" or foot also became a synonym of root. Brahma-Gupta defines square-root as follows :

> The *pada* (root) of a *kṛti* (square) is that of which it is the square.[1]

While the word *mūla* for *root* is the oldest in Indian literature (it occurs in *Anuyogadvāra-sūtra*, c. 100 B.C.), the word *pada* for root probably for the first time occurs in the writings of Brahmagupta. The term *mūla* was borrowed by the Arabs who translated it by *jadhr*, meaning "basis of square". The Latin term *radix* also is a translation of the term *mūla*. In the Śulba literature and in the Prākṛta texts, we find a term *karaṇī* for square-root. In geometry, this term *karaṇī* means a "side", In later days, the term *karaṇī* was reserved for surds, i.e. a square-root which cannot be exactly evaluated, but which may be represented by a line.

We would like to quote here a rule for determining square-root of numbers from the *Āryabhaṭīya* :

> Always divide the even place by twice the square-root (upon the preceding odd place); after having subtracted from the odd place the square (of the quotient), the quotient put down at the next place (in the line of the root) gives the root[2].

As an illustration, we shall proceed to find the square-root of 18225.

The odd and even places are marked out by vertical (I) and horizontal (—) lines : The other steps are as follows :

---

1. पदं कृतिर्यत् तत् — *BrSpSi.* XVIII. 35

2. भागं हरेदवर्गान्नित्यं द्विगुणेन वर्गमूलेन ।
वर्गाद्वर्गे शुद्धे लब्धं स्थानान्तरे मूलम् ॥ — *Ārya*, II. 4.

	I – I – I 1 8 2 2 5	
Subtract square	1	root = 1
Divide by twice the root	2) 8 (3 6	placing quotient at the next place, the root=13
	22	
Subtract square of quotient	9	
Divide by twice the root	26)132(5 130	placing quotient at the next place, the root=135
Subtract square of the quotient	25 25	

The process ends. The square-root of 18225 is thus 135.

It has been stated by Kaye, that Āryabhaṭa's method of finding out the square-root is algebraic in character, and that it resembles the method given by Theon of Alexandria. Āryabhaṭa's method is purely atithmetic and not algebraic is the view of Datta and Singh who do not agree with Kaye on this point.

Cube Root

The Sanskrit term for cube-root is *ghanamūla* or *ghanapada*. The first mention of the operation of cube-root is found in the *Āryabhaṭīya* of Āryabhaṭa I (499 A.D.), though the operation is given in only a concise form:

> Divide the second *aghana* place by thrice the square of the cube-root; subtract from the first *aghana* place the square of the quotient multiplied by thrice the preceding (cube-root); and (subtract) the cube (of the quotient) from the *ghana* place; (the quotient put down) at the next place (in the line of the root) gives (the root).[1]

As has been explained by all the commentators on the *Āryabhaṭīya*, the units place is *ghana*; the tens place is first *aghana*, the hundreds place is the second aghana, the thousands place is ghana, the ten thousands place is first *aghana*, the hun-

1. अघनाद् भजेद् द्वितीयात् त्रिगुणेन घनस्य मूलवर्गेण ।
वर्गस्त्रिपूर्वं गुणितश्शोध्यः प्रथमाद् घनश्च घनात् ॥ —*Ārya.* II. 5

dred-thousands place is second *aghana*, and so on. Thus to find out the cube-root, one has to mark out the *ghana*, first *aghana* and second *aghana* places, then the process of finding out the cube-root begins with the subtraction of the greatest cube number from the figures up to the last *ghana* place. Though this has not been explicitly mentioned in the rule, the commentators say that it is implied in the expression *ghanasya mūla-vargeṇa* etc. ("by the square of the cube-root etc.")

We are reproducing here an illustration given by Datta and Singh.

Example. Find the cube-root of 1953125.

The places are divided into groups of three by marking them as below [*ghana* (|) first *aghana* (—) and second *aghana* (—)]:

	| — — | — — |		
	1 9 5 3 1 2 5		
Subtract cube	1		(c) Root=1
Divide by thrice square of root, i.e. 3.1^2	3)9(2	...	(a) Placing quotient after the root 1 gives the root 12
Subtract square of quotient multiplied by thrice the previous root, i.e. $2^2.3.1$	6		
	35		
	12	...	(b)
Subtract cube of quotient, i.e. 2^3	233		
	8	...	(c)
Divide by thrice square of the root, i.e. 3.12^2	432)2251(5	...	(a) Placing quotient after the root 12 gives the root 125
Subtract square of quotient multiplied by thrice the previous root, i. e. $5^2.3.12$	2160		
	912		
	900		
Subtract cube of quotient, i.e. 5^3	125	...	(b)
	125	...	(c)

Thus the cube-root=125.

From the details given, it would be clear that the present

method of extracting the cube-root is almost a contraction of the method first given by Āryabhaṭa I (499 A.D.)

The method of Āryabhaṭa has been invariably followed by Indian mathematicians. Brahmagupta in his *Brāhmasphuṭa-siddhānta* repeats the method in the following words :

> The divisor for the second *aghana* place is thrice the square of the cube-root; the square of the quotient multiplied by three and the preceeding (root) must be subtracted from the next (*aghana* place to the right). and the cube (of the quotient) from the *ghana* place (the procedure repeated gives) the root.[1]

Śrīdhara and Āryabhaṭa II have further improved on the method of extracting cube-root proposed by Āryabhaṭa I and followed by Brahmagupta. Rule for finding the cube-root as given by Śrīdhara in his *Pāṭīgaṇita* is as follows :

> (Divide the digits beginning with the units' place into periods of) one *ghana*-pada (one "cube" place) and two *aghana-padaṣ* (two "non-cube" places). Then subtracting the (greatest possible) cube from the (last) *ghana-pada* and placing the (cube) root underneath the third place (to the right of the last *ghana-pada*), divide out the remainder up to one place less (than that occupied by the cube root) by thrice the square of the cube-root, which, is not destroyed. Setting down the quotient (obtained from division) in the line (of the cube-root), (and designating the quotient as the 'first' (*ādima*) and the cube-root as the 'last' (*antya*), subtract the square of that quotient, as multiplied by thrice the 'last' (*antya*) from one place less than that occupied by the quotient (*uparima-rāśi*) as before, and the cube of the 'first' (*ādima*) from its own place.
>
> (The number now standing in the line of cube-root is the cube-root of the given number up to its last-but one *ghana-pada* (cube place) from the left).
>
> Again apply the rule, "(placing cube-root) under the third place" etc. (provided there be more than two *ghana-padas* (cube places) in the given number; and

1. छेदो घनाद् द्वितीयाद् घनमूलकृतिस्त्रिसंगुणाप्तकृतिः ।
शोध्या त्रिपूर्वगुणिता प्रथमाद् घनतो घनो मूलम् ॥ —*BrSpSi.* XII. 7

continue the process till all *ghana-padas* (cube-places) are exhausted). This will give the (cube) root (of the given number).[1]

K.S. Shukla in his translation and commentary of this book has given the illustration of extracting cube-root as follows :

Example :- To find the cube root of 277167808.

Let us indicate *ghana-padas* or 'cube' places by "*c*" and *aghana-padas* or non-cube places as "*n*" :

n n c n n c n n c
2 7 7 1 6 7 8 0 8

Subract the greatest possible cube (i.e. 6^3 or 216) from the last 'cube' place (i.e. from 277) and place the cube-root (i.e. 6) underneath the third place to the right of the last 'cube' place; thus we have

n n c n n c n n c
6 1 1 6 7 8 0 8 (remainder)
6 (line of cube-root)

Dividing out by thrice the square of the cube-root (i.e. by 3.6^2 or 108) the remainder up to one place less than that occupied by the cube-root (i.e. 611) and setting down the quotient in the line of the cube-root (to the right of the cube-root), we have

n n c n n c n n c
7 1 6 7 8 0 8 (remainder)
6 5 (line of cube-root)

Let now quotient 5 be called the 'first' (*ādima*) and the cube-root 6 the 'last' (*antya*). Then subtracting the square of the 'first' (*ādima*) as multiplied by thrice the 'last' (*antya*) (i.e. $3 \times 6 \times 5^2$ or 450) from one place less than that occupied by the quotient (i.e. from 716), we get

1. घनपदमघनपदे द्वे घन (पद) तोऽपास्य घनमदो मूलम् ।
संयोज्य तृतीयपदस्याधस्तदनष्टवर्गेण ॥ २९ ॥
एकस्थानोनतया शेषं त्रिगुणेन (सं) भजेत्तस्मात् ।
लब्धं निवेश्य पङ्क्त्यां तद्वर्गं त्रिगुणमन्त्यहतम् ॥ ३० ॥
जह्यादुपरिमराशेः प्राग्वद् घनमादिमस्य (च) स्वपदात् ।
भूयस्तृतीय पदस्याथ इत्यादिक विधिमूलम् ॥ ३१॥

—Śrīdhara, *Pāṭīgaṇita*, 29-31

n n c n n c n n c

2 6 6 7 8 0 8	(remainder)
6 5	(line of cube-root)

And subtracting the cube of the 'first' (*ādima*) (i.e. 5^3 or 125) from its own place (i.e. from 2667), we get

n n c n n c n n c

2 5 4 2 8 0 8	(remainder)
6 5	(line of cube-root)

One round of the operation is now over; and the number 65 standing in the line of the cube-root is the cube-root of the given number (277167808) up to its last-but-one 'cube' place (*ghana pada*) from the left (i.e. of 277167),

As there is one more 'cube' place (*ghana-pada*) on the right, the process is repeated, Thus placing the cube-root (i.e. 65) under the third place beginning with the last-but-one 'cube' place (*ghana-pada*), we have

n n c n n c n n c

2 5 4 2 8 0 8	(remainder)
6 5	(line of cube-root)

Dividing out 25428 by 3.65^2 (=12675) as before, and placing the quotient in the line of the cube-root, we have

n n c n n c n n c

7 8 0 8	(remainder)
6 5 2	(line of cube-root)

Subtracting $3 \times 65 \times 2^2$ (=780) we get.

n n c n n c n n c

8	(remainder)
6 5 2	(line of cube-root)

Finally subtracting $2^3=8$ from 8, we get

n n c n n c n n c

0	(remainder)
6 5 2	(line of cube-root)

The second round of operation is now over. There being no more of *ghana-pada* ('cube' place) on the right, the process ends, The quantity in the line of cube root, viz., 652, is the cube-root of the given

number. The remainder being zero, the cube-root is exact.

Fractions

The concept of fractions in India can be traced to very early times. In the *Ṛgveda*,[1] we find such terms as one-half (*ardha*) and three-fourths (*tri-pāda*). In a passage of the *Maitrāyaṇī Saṁhitā*[2] are mentioned the fractions one-sixteenth (*kalā*), one-twelfth (*kuṣṭha*), one-eighth (*śapha*) and one-fourth (*pāda*). In the *Śūlba Sūtras*[3] we have not only a mention of fractions, but they have been used in the statement and solution of problems of geometric nature. Here in the *Śulba*, unit fractions are denoted by the use of cardinal number with the term *bhāga* or *aṁśa*; thus *pañca-daśa-bhāga* (literally "fifteen parts") is equivalent to one-fifteenth, *sapta-bhāga* (literally, "seven parts") is equivalent to one-seventh, and so on... The use of ordinal numbers with the term *bhāga* or *aṁśa* is also quite common: thus *pañcama bhāga* stands for one-fifth. The composite fractions like *tri-āṣṭama* stands for three-eighths and *dvi-saptama* for two-sevenths. In the *Bakhaśālī Manuscript*, the term *tryaṣṭa* occurs for 3/8 and $3\frac{3}{8}$ is called *trayastrayasta* (three-three-eighths).

The Sanskrit term for fraction is *bhinna* (literally meaning 'broken'). Obviously the European terms as *fractio, fraction, roupt, rotto* or *rocto* are translations of the same term; they are derived from the Latin *fractus (frangere)* or *ruptus* meaning 'broken'. The Indian term *bhinna* has a few more connotations; it stands for such numbers of the form :

$$\left(\frac{a}{b}\pm\frac{c}{d}\right), \left(\frac{a}{b} \text{ of } \frac{c}{d}\right), \left(\frac{a}{b}\pm\frac{c}{d} \text{ of } \frac{a}{b}\right) \text{or} \left(a\pm\frac{b}{c}\right).$$

These forms were termed *jāti*' i.e., 'classes', and the Indian treatises contain special rules for their reduction to proper fractions. Śrīdhara and Mahāvīra each enumerate six *jātis*. while our author, Brahmagupta, gives only five (Bhāskara II gives only four). The need for division of fractions in 'classes' arose out of the lack of proper symbolism to indicate mathematical operations. (Datta and Singh *Arithmetic*, p. 188). The only operational symbol in use was a dot, standing for the negative sign.

1. *Rv*. X. 90.4
2. *Mait* S. III. 7.7.
3. B. Datta, *Śulba*, pp. 212ff.

Reduction to lowest terms.—A non-mathematical work, *Tattvārthādhigama-Sūtra-Bhāṣya* by Umāsvāti (c.150 A.D.) casually mentions as follows in the context of a philosophic discourse:

> Or, as when the expert mathematician, for the purpose of simplifying operations, removes common factors from the numerator and denominator of a fraction, there is no change in the value of the fraction, so,...[1]

Reduction to common denominator. Whenever we have to add or subtract fractions, we follow this reduction operation to a common denominator. Brahmagupta gives the reduction along with the similar processes :

> By the multiplication of the numerator and denominator of each of the (fractional) quantities by other denominators, the quantities are reduced to a common denominator. In addition, the numerators are united, In subtraction their difference is taken.[2]

Fractions in combination :—Since there was no proper symbolism available to these early Indian mathematicians, they divided combination of fractions into four classes :

Bhāga, prabhāga, bhāgāpavāha and *bhāga-bhāga.*

(i) *Bhāga* has been mentioned by Brahmagupta (*BrSpSi.* XII, 8) thus : $\left(\frac{a}{b}\pm\frac{c}{d}\pm\frac{e}{f}\pm\ldots\ldots\ldots\right)$ usually written as

$$\begin{array}{|c|c|c|}\hline a & c & e \\ b & d & f \\ \hline\end{array} \text{ or } \begin{array}{|c|c|c|}\hline a & .c & .e \\ b & d & f \\ \hline\end{array}$$

where the dots denote subtraction.

(ii) *Prabhāga* : The form $\left(\frac{a}{b} \text{ of } \frac{c}{d} \text{ of } \frac{e}{f}\ldots\ldots\ldots\right)$

This is written as

$$\begin{array}{|c|c|c|}\hline a & c & e \\ b & d & f \\ \hline\end{array}$$

(iii) *Bhāgānubandha* :The form $\left(a+\frac{b}{c}\right)$ is written as

$$\begin{array}{|c|}\hline a \\ b \\ c \\ \hline\end{array}$$

1. II, 52.
2. विपरीतच्छेदगुणा : राश्योश्छेदांशकाः समच्छेदाः ।
संकलितेऽशा योज्या व्यवकलितेऽशान्तरं कार्यम् ॥ —*BrSpSi.* XII. 2.

and the form

$$\frac{p}{q}+\frac{r}{s} \text{ of } \frac{p}{q}+\frac{t}{u} \text{ of}\left(\frac{p}{q}+\frac{r}{s} \text{ of} \frac{p}{q}\right)+\ldots\ldots\ldots$$

is written as

$$\begin{array}{|c|}\hline p\\ q\\ \hline r\\ s\\ \hline t\\ u\\ \hline\end{array}$$

(iv) *Bhāgāpavāha*, i.e., the form $\left(a-\frac{b}{c}\right)$ is written as

$$\begin{array}{|c|}\hline a\\ .b\\ c\\ \hline\end{array}$$

and the form $\frac{p}{q}-\frac{r}{s} \text{ of} \frac{p}{q}-\frac{t}{u} \text{ of}\left(\frac{p}{q}-\frac{r}{s} \text{ of } \frac{p}{q}\right)-\ldots\ldots\ldots$

is written as

$$\begin{array}{|c|}\hline p\\ q\\ \hline .r\\ s\\ \hline .t\\ u\\ \hline\end{array}$$

(v) Bhāga-bhāga : The form

$$\left(a\div\frac{b}{c}\right) \text{ or}\left(\frac{p}{q}\div\frac{r}{s}\right)$$

There does not appear to have been any notation for division, such compounds being written as

$$\begin{array}{|c|}\hline a\\ b\\ c\\ \hline\end{array} \text{ or } \begin{array}{|c|}\hline p\\ q\\ \hline r\\ s\\ \hline\end{array}$$

just as for *bhāgānubandha*. That division is to be performed was known from the problem, e.g., $1\div\frac{1}{6}$ was written as ṣaḍ-bhāga-bhāga, i.e., "one-sixth *bhāga-bhāga*" or "one divided by one-sixth". It is only in the Bakhśālī Manuscript that the term *bhā* is sometimes placed before or after the quantity affected.

(vi) *Bhāga-mātṛ*, i.e., combinations of forms enumerated above. Mahāvīra, the author of the *Gaṇitasārasaṁgraha* (850

A.D.) gives twenty-six variations of this class. We shall illustrate it by the following example from Śrīdhara :

> What is the result when half, one-fourth of one-fourth, one divided by one-third, half-plus half of itself, and one-third diminished by half of itself, are added together ? (*Triśatikā*, p. 12).

A modern writer would have written it as :

$\frac{1}{2}+(\frac{1}{4}\text{ of }\frac{1}{4})+(1\div\frac{1}{3})+(\frac{1}{2}+\frac{1}{2}\text{ of }\frac{1}{2})(\frac{1}{3}-\frac{1}{2}\text{ of }\frac{1}{3})$

In the old Indian notation, it is written as

1	1	1	1	1	1
2	4	4	1	2	3
			3	1	.1
				2	2

The defect of the notation is obvious:

1	1
4	4

can be read also as $\frac{1}{4}+\frac{1}{4}$ and

1
1
3

can also be read as $1\frac{1}{3}$.

And therefore the original meaning is inferred from the context or from the enunciation of the problem.

The rules for reduction of the first two classes *(bhāga* and *prabhāga)* are those of addition or subtraction and multiplication. The rule for the reduction of the third *(bhāgānubandha)* and fourth *(bhāgāpavāha)* classes are given by Brahmagupta in the *Brāhmasphuṭa-siddhānta* thus :

> The (upper) denominator is multiplied by the denominator and the upper numerator by the same (denominator) increased or diminished by its own numerator.[1]

"Numerator" is known as "*aṁśa*" and the "denominator" as "*cheda*."

We give here from Śrīdhara's *Pāṭigaṇita* (about 900 A.D., according to K.S. Shukla, 750 A.D. according to Datta and Singh) a rule for reducing a fraction of the *bhāgānubandha* class (i.e., a whole number increased by a fraction or a fraction increased by a fraction itself) :

1. ऊर्ध्वांशाश्छेदगुणास्तृतीयजातौ द्वयोः पृथक्परयोः ।
छेदैश्छेदा गुणिताः स्वांशयुतोनैरुपरिमांशाः ॥ —*BrSpSi. XII. 9.*

> In the *bhāgānubandha* class, the whole number (*rūpa-gaṇa*) is multiplied by the denominator (of the fraction) should be increased by the numerator (of the fraction) or the upper denominator having been multiplied by the lower denominator, the initial numerator (i.e. the upper numerator) should be multiplied by the sum of the lower numerator and denominator.[1]

(*Pāṭīgaṇita*, 39 *cf*. *BrSpSi*. *XII*. 9 (*ii*); *GSS*. (iii) 113

This means that

(i) $a+\frac{b}{c}=\frac{ac+b}{c}$

(ii) $\frac{a}{b}+\frac{c}{d}$ of $\frac{a}{b}$ (which was written by Indians in the style

$$\begin{array}{|c|}\hline a \\ \overline{b} \\ c \\ \overline{d} \\ \hline\end{array}$$

is equal to $\frac{a(d+c)}{bd}$

Addition and Subtraction of Fractions

In the *Brāhmasphuṭa-siddhānta*, Brahmagupta gives the rule for the addition and subtraction of fractions :

> If the denominators (*cheda*) of fractions are different then reduce these fractions to a common denominator. Now for the additions, unite the numerators and take their difference in case of subtraction.[2]

Brahmagupta and Mahāvīra give the method under *Bhāga-jāti*.

Multiplication

Brahmagupta says :

The product of the numerators divided by the pro-

---

1. भागानुबन्धजातौ रूपगणश्छेद सङ्गुणः सांशः ।
अवरहरघ्नोर्ध्वं हरेऽधोंशाऽयुतहरघ्न आद्यंशः ॥ —*Pāṭīgaṇita 39.*

2. विपरीतच्छेदगुणाः राश्योश्छेदांशकाः समच्छेदाः ।
संकलितेंऽशा योज्या व्यवकलितेंऽशान्तरं कार्यम् ॥ —*BrSpSi*. XII. 2

duct of the denominators is the (result of) multiplication of two or more fractions.[1]

While all other writers give the rule in the same way as Brahmagupta, Mahāvīra in the *Gaṇitasārasaṁgraha* refers to cross reduction in order to shorten the work :

> In the multiplication of fractions, the numerators are to be multiplied by the numerators and the denominators by denominators, after carrying out the process of cross reduction, if that be possible.[2]

Division of Fractions

The *Āryabhaṭīya* does not explicitly give the rule of division, but under the Rule of Three, we have an indication of this operation. The Rule of Three states the result as $\frac{f \times i}{p}$, where f stands for *phala* i.e. "fruit", i for *icchā*, i.e., demand or requisition, and p for *pramāṇa* i.e. argument. When these quantities are fractional, we get an expression of the form

$$\frac{\frac{a}{b} \times \frac{c}{d}}{\frac{m}{n}}$$

for the evaluation of which Āryabhaṭa I states :

> The multipliers and the divisor are multiplied by the denominators of each other.

These quantities are written in the following way

$$\left|\begin{array}{cc} a & m \\ b & n \\ \hline c & \\ d & \end{array}\right|$$

Transferring the denominators we have

$$\left|\begin{array}{cc} a & m \\ n & b \\ c & d \end{array}\right|$$

Performing multiplication, the result is $\frac{anc}{mbd}$. The above interpretation of the obscure line in the *Āryabhaṭīya* is based

1. रूपाणिच्छेद गुणान्यंशयुतानि द्वयोर्बहूनां वा ।
प्रत्युत्पन्नो भवति च्छेदवधेनोद्धृतोऽशवधः ॥ —*BrSpSi*. XII. 3

2. GSS. p. 25. (2)

on the commentaries of Sūryadeva and Bhāskara I (the commentary of Parameśvara on this line is vague and misleading). Sūryadeva in this connection says :

> Here by the word *guṇakāra* is meant the multiplier and multiplicand, i.e., the *phala* and *icchā* quantities that are multiplied together. By *Bhāgahāra* is meant the *pramāṇa* quantity. The denominators of the *phala* and *icchā* are taken to the *pramāṇa*. The denominator of the *pramāṇa* is taken with the *phala* and *icchā*. Then multiplying these, i.e., (the numerators of) the *phala* and *icchā* and this denominator, and dividing by (the product of) the numbers standing with the *pramāṇa* the result is the quotient of the fractions.

Brahmagupta gives the method of division as follows :

> The denominator and numerator of the divisor having been interchanged, the denominator of the dividend is multiplied by the (new) numerator. Thus division of *proper fractions* is performed.[1]

Square and Square-Root of Fractions

Brahmagupta says as follows in this connection:—

> The square of the numerator of a proper fraction divided by the square of the denominator gives the square[2].

This rule of Brahmagupta has been followed by other authors also. The rule regarding the square-root as given by Brahmagupta is as follows :

> The square-root of the numerator of a proper fraction divided by the square-root of the denominator gives the square-root.[3]

The Rule of Three :

The Indian term in Sanskrit for the Rule of Three is *Trairāśika* (literally, "three terms"). The term occurs in the *Bakhśālī Manuscript* also, and also in the *Āryabhaṭīya*, indicating the

1. परिवर्त्य भागहारंच्छेदांशौ छेद संगुणच्छेदः ।
अंशोऽशगुणो भाज्यस्य भागहारः सवर्णितयोः ॥ —*BrSpSi*. XII. 4

2. संवर्णितांशवर्गश्छेदकृतिविभाजितो भवति वर्गः । —*BrSpSi*. XII. 5 (1)

3. संवर्णितांशमूलं छेदपदेनोद्धृतं मूलम् । —*BrSpSi*. XII. 5 (2)

antiquity of the term. Bhāskara in his commentary of the *Āryabhāṭīya* gives a justification of the use of this term for the Rule of Three thus :

> Here three quantities are needed (in the statement and calculation) so the method is called *trairāśika* (meaning thereby the "rule of three terms").

The problem of the Rule of Three has the form :

> If p (*pramāṇa*) yields f (*phala*), what will i (*icchā*) yield ?

Āryabhaṭa II (the author of the *Mahāsiddhānta*, 950 A.D.) uses the terms *māna*, *vinimaya* and *icchā*, instead of *pramāṇa*, *phala* and *icchā* respectively. It has also been pointed out by several authors that the first and third terms are similar, i.e., of the same denomination.

We shall give here the Rule of Three as given by Āryabhaṭa I and Brahmagupta :

> In the Rule of Three, the *phala* ("fruit"), being multiplied by the *icchā* ("requisition') is divided by the *pramāṇa* ("argument"). The quotient is the fruit corresponding to the *icchā* The denominators of one being multiplied with the other give the multiplier (i.e. numerator) and the divisor (i.e. denominator).[1]
> In the Rule of Three *pramāṇa* ("argument"), *phala* ("fruit") and *icchā* ("requisition") are the (given) terms; the first and the last terms must be similar. The *icchā* multiplied by the *phala* and divided by the *pramāṇa* gives the fruit (of the demand).[2]

Śrīdhara also gives the Rule of Three almost in the same words. Bhāskara II, Nārāyaṇa and others follow Brahmagupta and Śrīdhara in the *Trairāśika* operation. Śrīdhara in his *Pāṭīgaṇita* says :

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1. त्रैराशिकफलराशिं तमथेच्छाराशिनाहतं कृत्वा ।
लब्धं प्रमाणभजितं तस्मादिच्छाफलमिदं स्यात् ॥
छेदाः परस्परं हता भवन्ति गुणकार भागहाराणां ।
छेदगुणं सच्छेदं परस्परं तत्सवर्णत्वम् ॥ —*Arya*. II 26-27.

2. त्रैराशिके प्रमाणं फलमिच्छाद्यन्तयोः सदृशराशी ।
इच्छाफलेन गुणिता प्रमाणभक्ता फलं भवति ॥ —*BrSpSi* XII. 10

> In (solving problems on) the Rule of Three, the argument (*pramāṇa*) and the requisition (*icchā*), which are of the same denomination, should be set down in the first and last places; the fruit (*phala*), which is of a different denomination, should be set down in the middle, (this having been done) that (middle quantity multiplied by the last quantity should be divided by the first quantity.[1]

We shall illustrate the Rule of Three by an example from the *Pāṭīgaṇita* (Example 25) :

> Example, If 1 *pala* and 1 *karṣa* of sandalwood are obtained for ten and a half *paṇas*, then for how much will nine *palas* and one *karṣa* (of sandalwood) be obtained ?[2]

Here in this Example.

argument=1 *pala* and 1 *karṣa*=$1\frac{1}{4}$ or 5/4 *palas*; fruit= $10\frac{1}{2}$ or 21/2 *paṇas*;

and requisition=9 palas and 1 karṣa=$9\frac{1}{4}$ or 37/4 palas. According to the Rule we shall write them as :

$$\begin{array}{|ccc|} 1 & 10 & 9 \\ 1 & 1 & 1 \\ 4 & 2 & 4 \end{array}$$

Converting these into proper fractions we have

$$\begin{array}{|ccc|} 5 & 21 & 37 \\ 4 & 2 & 4 \end{array}$$

Then applying the rule, (i.e. multiplying the second and the last and dividing by the first), we have

$$\begin{array}{|cc|} 21 & 5 \\ 2 & 4 \\ \hline 37 & \\ 4 & \end{array} \qquad = \frac{\frac{21}{2} \times \frac{37}{4}}{\frac{5}{4}}$$

Or transferring denominators $\begin{array}{|cc|} 21 & 5 \\ 4 & 2 \\ 37 & 4 \end{array} = \frac{21.4.37}{5.2.\ 4}$ *pala*

1. आद्यन्तयोस्त्रिराशावभिन्नजाती प्रमाणमिच्छा च।
फलमन्यजातिमध्ये तदन्त्यगुणमादिना विभजेत्॥ —*Pāṭīgaṇita* 43.

2. चन्दनपलं सकर्षं सार्धैर्यदि लभ्यते पणैर्दशभिः।
तत्किं कृता लभ्यन्ते पलानि नव कर्षयुक्तानि॥ —*Pāṭīgaṇita*. Ex. 25.

=4 purāṇa, 13 paṇas, 2 kākiṇīs and 16 varāṭakas. (One purāṇa is equivalent to 16 paṇas; one paṇa is equivalent to 4 kākiṇīs, and one kākiṇī is equivalent to 20 varāṭakas or cowries.

Inverse Rule of Three

This is known as *vyasta-trairāśika* (literally meaning "inverse rule of three terms)". After having described the rule of three, Brahmagupta proceeds to give an account of this inverse rule of three :

> Divide the *phala* with *icchā* and multiply by *pramāṇa*; this gives the *vyasta-trairāśika* inverse rule of three[1].

Here *pramāṇa* is the argument also known as the first term and, and *phala* is the fruit also known as the middle term and *iccha* is known as requisition or the last term. As Bhāskara II clearly states, this rule is applied where with the increase of the *icchā*, the *phala* decreases or with its decrease the *phala* increases (*Līlāvatī*).

Rule of Compound Proportion

Brahmagupta and other writers call the rule of compound proportions as *pañca-rāśika*, *sapta-rāśika* etc., meaning the rule of five terms, rule of seven terms etc. depending on the number of terms involved the problems. These are sometimes grouped under the general application of the "Rule of Odd Terms". Āryabhaṭa I (499 A.D.) though actually gives the rule of three appears to have been quite familiar with the rule of compound proportion also. In fact the difference between the rule of three and compound proportion is more or less artificial. This view was expressed by Bhāskara I (525 A.D.) in his commentary on the *Āryabhaṭīya* :

> Here Ācārya Āryabhaṭa has described the Rule of Three only. How the well-known Rules of Five etc. are to be obtained ? I say thus : The Ācārya has described only the fundamentals of *anupāta* (proportion). All others such as the Rule of Five etc. follow from that fundamental rule of proportion. How ? The Rule of Five etc. consist of combinations of the Rule of Three. ......In the Rule of Five, there are two Rules of

1. व्यस्त त्रैराशिक फलमिच्छा भक्तः प्रमाण फलघातः ।
त्रैराशिकादिषु फलं विषमेष्वेकादशान्तेषु ॥ —*BrSpSi* XII. 11

> Three, in the Rule of Seven three Rules of Three, and so on. This I shall point out in the examples.

Brahmagupta gives the following rule relating to the solution of problems in compound proportion :

> In the case of odd terms beginning with three terms up to eleven, the result is obtained by transposing the fruits of both sides, from one side to the other, and then dividing the product of the larger set of terms by the product of the smaller set. In all the fractions, the transposition of denominators, in like manner, takes place on both sides.[1]

This may be illustrated by taking an example from the commentary of Pṛthūdaka Svāmī on the *Brāhmasphuṭasiddhānta* :

Example —If there is an increase of 10 in 3 months on 100 (*niṣkas*), what would be the increase on 60 (*niṣkas*) in 5 months.

Here the *Pramāṇa pakṣa* (the first set of terms) is
100 niṣkas, 3 months, 10 niṣkas (phala)

The second set or the *icchā pakṣa* is
60 *niṣkas*, 5 months, *x niṣkas*

The terms are written in compartments as below :

100	60
3	5
10	0

In the above 10 (written lowest) is the *fruit* of the first side (*pramāṇa pakṣa*), and there is no *fruit* on the second side or the *iccā pakṣa*. Interchanging the *fruits* we get

100	60
3	5
0	10

The larger set of terms is on the second side (*icchā pakṣa*). The product of the numbers is 3,000. The product of the

1. व्यस्त त्रैराशिक फलमिच्छा भक्तः प्रमाणफलघातः ।
त्रैराशिकादिषु फलं विषमेष्वेकादशान्तेषु ॥
फलसंक्रमणमुभयतो बहुराशि वधोऽल्पवधहृतो ज्ञेयम् ।
सकलेष्वेवं भिन्नेषूभयतश्छेदसंक्रमणम् ॥ —*BrSpSi*: XII. 11-12.

number on the side of the smaller set of terms is 300. Therefore the required result is $\frac{3000}{300}=10$.

Rule of Three as a Particular Case

According to Brahmagupta, the above method of "compound proportion" may be applied to the Rule of Three. Taking the example solved under the Rule of Three:

> If one *pala* and one *karṣa* of sandal wood are obtained for ten and a half *paṇas*, for how much will be obtained nine *palas* and one *karṣa*?
>
> (4 karṣas=1 pala)

We shall represent them according to the Rule of Compound Proportion as

Pramāṇa pakṣa : 1 *pala*, 1 *karṣa*, $10\frac{1}{2}$ *paṇa*
or $\frac{5}{4}$ *pala* , $\frac{21}{2}$ *paṇa*
Icchā pakṣa : 9 *pāla*, 1 *karṣa*, x *paṇa*
or 37/4 *pala* , x *paṇa*

This we shall represent as

$$\begin{array}{|cc|}\hline 5 & 37 \\ 4 & 4 \\ \hline 21 & 0 \\ 2 & \\ \hline\end{array}$$

Transposing the fruits, we have

$$\begin{array}{|cc|}\hline 5 & 37 \\ 4 & 4 \\ \hline 0 & 21 \\ & 2 \\ \hline\end{array}$$

Transposing denominators

$$\begin{array}{|cc|}\hline 5 & 37 \\ 4 & 4 \\ \hline 0 & 21 \\ 2 & \\ \hline\end{array}$$

The product of numbers on the side of the larger set is divided by the product of the numbers on the side of the smaller set, 0 in this case is not a number. It is the symbol for the unknown or absence, Hence the result is :

$$\frac{37.4.21}{5.4.2} \textit{ paṇas}$$

> The above method of working Rule of Three is found among Arabs, although it does not seem to have been used in India after Brahmagupta.

Problem Containing Quadratic Equation

Perhaps Āryabhaṭa I is the first man in the history of mathematics to give a solution of a quadratic equation (499 A.D.). In his *Āryabhaṭīva*, he gives a rule for the solution of the following problem (I am reproducing it as described by Datta and Singh) :

> The principal sum $p\,(=100)$ is lent for one month (interest unknown$=x$). This unknown interest is then lent out for $t(=\text{six})$ months. After this period, the original interest (x) plus the interest on this interest amounts to $A(=16)$. The rate-interest (x) on the principal (p) is required.

This problem requires the solution of the quadratic equation :—

$$tx^2+px-AP=0$$

which gives $x=\dfrac{-p/2\pm\sqrt{(p/2)^2+Apt}}{t}$

The negative value of the radical does not give a solution of the problem; so that the result is

$$x=\frac{\sqrt{Apt+(p/2)^2}-p/2}{t}$$

This solution is stated by Āryabhaṭa I in the following words :

> Multiply the sum of the interest on the principal and the interest (A) by the time (t) and by the principal (p). Add to this result the square of half the principal $(p/2)^2$. Take square-root this. Subtract half the principal $(p/2)$ and divide the remainder by the time (t). The result will be the (unknown) interest (x) on the principal.[1]

Here the Sanskrit terms are *mūla* for principal and *phala* for interest.

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1. मूलफलं सफलं कालमूलगुणमर्धमूलकृतियुक्तं ।
मूलं मूलार्धोनं कालहृतं स्यात्स्वमूलफलम् ॥ *Ārya, II. 25,*

Brahmagupta (628 A.D.) gives a more general rule: He enunciates his problem thus:

> The principal (p) is lent out for t_1 months and the unknown interest on this ($=x$) is lent out for t_2 months at the same rate and becomes A. To find x.

This evidently gives the quadratic:

$$x^2+\frac{pt_1}{t_2}\ x-\frac{Apt_1}{t_2}=0$$

whose solution is

$$x=\pm\sqrt{\frac{Apt_1}{t_2}+\left(\frac{pt_1}{2t_2}\right)^2}-\frac{pt_1}{2t_2}$$

The negative value of the radical does not give a solution of the problem, so it is discarded.

Brahmagupta states the formula thus:

> Multiply the principal (p) by its time (t_1) and divide by the other time (t_2) (placing the result) at two places. Multiply the first of these by the mixture (A). Add to this the square of half the other. Take the square-root of this (sum). From the result subtract half the other. This will be the interest (x) on the principal.[1]

A Problem on Interest

Brahmagupta gives a solution of a problem on interest:

> In what time will a given sum s, the interest on which for t months is r, become k times itself?

The rule for the solution of this problem as given by Brahmagupta is:

> The given sum multiplied by its time and divided by the interest (*phala*), being multiplied by the factor (*guṇa*) less one, is the time (*required*).[2]

Miscellaneous Problems

Brahmagupta in his *Gaṇitādhyāya* of the *Brāhmasphuṭa-siddhānta* gives numerous solutions in relation to miscellaneous problems. Here I shall be quoting a few of the problems which

1. कालप्रमाणघातः परकालहृतो द्विधाऽऽद्यमिश्रवधात् ।
अन्यार्धकृतियुतात् पदमन्यार्धोनं प्रमाणफलम् ॥ —*BrSpSi*. XII. 15.

2. कालगुणितं प्रमाणं फलभक्तं व्येकगुणहतं कालः ।
स्वफलयुतरूपभक्तं मूलफलैक्यं भवति मूलम् ॥ —*BrSpSi*. XII. 14.

have been quoted by his commentator Pṛthūdaka Svāmī in connection with one of his karaṇa-sūtra.[1]

> 1. A horse was purchased by (nine) dealers in partnership, whose contributions were one, etc. up to nine; and was sold by them for five less than five hundred. Tell me what was each man's share of the sale proceed[2]
> 2. Four colleges (mathas), containing an equal number of pupils, were invited to partake of a sacrificial feast. A fifth, a half, a third and a quarter (of the total number of pupils in the college) came from the respective colleges to the feast; and added to one, two, three and four, they were found to amount to eighty-seven; or, with those deducted, they were sixty seven. Find the actual number of the pupils that came from each college.[3]
>
> 3. Three (unequal) jars of liquid butter, of water and of honey, contained thirty-two, sixty and twenty-four *Pala* respectively; the whole was mixed together and the jars filled again. Tell me the quantity of butter, of water and of honey in each jar[4].

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1. प्रक्षेपयोगहृतया लब्ध्वा प्रक्षेपका गुणा लाभाः ।
उनाधिकोऽऽरास्तद्युतोनया स्वफलमूनयुत ॥ *BrSpSi*. XII. *16*.

2. एकाद्यैर्नव पर्यन्तैर्वणिग्भिर्मूलराशिभिः ।
क्रीतो हयोऽसौ विक्रीतः पञ्चोनैः पञ्चोनैः पंचभिः शतैः ।
किमेकैकस्य तत्रासीद् ब्रूहि त्वं मिश्रकान् मम ॥

3. मठस्थानानि चत्वारि छात्राणां समसंख्यया ।
भोक्तुं संमन्त्रितान्यासन् दीक्षायां किल यज्वना ॥
पंचार्धत्रिचतुर्थांशास्तेभ्यो भोक्तुं समागताः ।
एकद्वित्रिचतुर्युक्ता दृष्टाशीतिः ससप्तका ॥
एवोत्तरैरथवा हीना सप्तषष्टिश्चतेंऽशकाः ।
मठेभ्यश्छात्रसंख्यां मे ब्रूहि ये चागता सतः

4. घृतोदक मधूनां ये त्रयः कलसकाः पलैः ।
रदषष्टिजिनैः पूर्णा एकीभूतास्ततः पुनः ॥
मिश्रेण पूरिता यावत् तावत् संख्यां न वेद्म्यहम् ।
घृतोदकमधूनां तामेकैकत्र गतां वद ॥

—:o:—

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CHAPTER IX

Brahmagupta as an Algebraist

Ancient Indian name for algebra is *Bījagaṇita* where *bīja* means *element* or *analysis* and *gaṇita* stands for the *science of calculation*. As early as 860 A.D., Pṛthūdaka Svāmi used this epithet for algebra in his commentary. Brahmagupta calls algebra as *Kuṭṭakagaṇita* or merely *kuṭṭaka*, a term which was later on used for "*pulveriser*" which deals with that special section of algebra which is connected with indeterminate equations of the first degree. Algebra is often also known as *avyakta-gaṇita* or the calculations with *unknowns*, in contrast to arithmetic which was known as *vyakta-gaṇita* or the calculations with *knowns*.

Algebra goes to Europe from India

In the history of mathematical sciences, as Colebrooke rightly remarks, it has long been a question to whom the invention of algebraic analysis is due. There is no doubt that Europe got algebra from Arabs mediately or immediately. But the Arabs themselves scarcely pretend to the discovery of algebra. Colebrooke says that they were not in general inventors but scholars during the short period of their successful culture of the sciences; and the germ at least of the algebraic analysis is to be found among the Greeks in an age not precisely determined, but more than probably anterior to the earliest dawn of civilisation among the Arabs; and this science in a more advanced state subsisted among the Hindus prior to the earliest disclosure of it by the Arabians to modern Europe. (Colebrooke: *Dissertation on the Algebra of the Hindus*)[1].

Colebrooke based his observations on the texts he could procure for his studies. These were: Bhāskara II's *Bījagaṇita* or *Vījagaṇita* (1150 A.D.) and *Līlāvatī* (1150 A.D.), the *Gaṇitādhyāya* and *Kuṭṭakādhyāya* of Brahmagupta in his famous treatise the *Brahma Siddhānta* or rather the *Brāhmasphuṭasiddhānta* (628

1. Colebrooke, H. T., *Miscellaneous Essays*, Vol. II, 1872, p. 418.

A.D.). There can be no doubt regarding the age of these two authors. Bhāskara II completed his great work on the *Siddhānta-śiromaṇi* in 1072 Śaka, and *Karaṇa-kutūhala* a practical astronomical treatise in 1105 Śaka; these dates are based on the passages given by Bhāskara himself in his works. The *Bīja-gaṇita* and the *Līlāvatī* form parts of the great treatise, the *Siddhānta-śiromaṇi*. The genuineness of the text is established, as Colebrooke says, with no less certainty by numerous commentators in Sanskrit, besides a Persian version of it. Those commentaries comprise a perpetual gloss, in which every passage of the original is noticed and interpreted : and every word of it is repeated and explained. From comparison and collation of various texts, it appears then that the work of Bhāskara, exhibiting the same uniform text which the modern transcripts of it do, was in the hands of both Muhammedans and Hindus, between two or three centuries ago : and numerous copies of it having been diffused throughout India, at an earlier period, as of a performance held in high estimation, It was the subject of study and habitual reference in countries and places so remote from each other as the north and west of India and the Southern Peninsula.

This though not marking any extraordinary antiquity, nor approaching to that of the author himself, was a material point to be determined : as there will be in the sequel, so says Colebrooke, occasion to show, that modes of analysis, and in particular, general methods for the solution of indeterminate problems both of the first and second degrees, are taught in the *Bīja-gaṇita*, and those for the first degrees repeated in the *Līlāvatī*, which were unknown to the mathematicians of the West, until invented anew in the last two centuries by algebraists of France and England.[1] Bhāskara who himself flourished more than six hundred and fifty years ago, was in this respect a compiler and took those methods from Indian authors as much more ancient than himself.

Regarding the age of the precursors of Bhāskara II, Colebrooke says : The age of his precursors cannot be determined with equal precision. He then proceeds to examine the evidence as follows :

1. Colebrooke, H. T., *Miscellaneous Essays*, p. 421.

Towards the close of his treatise on Algebra, Bhāskara II informs us, that it is compiled and abridged from the more diffuse works on the same subject, bearing the names *Brāhme* (meaning no doubt Brahmagupta), Śrīdhara and Padmanābha; and in the body of his treatise, he has cited a passage of Śrīdhara's algebra and another of Padmanābha. He repeatedly adverts to preceding writers and refers to them in general terms, where his commentators understand him to allude to Āryabhaṭa, to Brahmagupta to the latter's scholiast Caturveda *Pṛthūḍaka Svāmī* and to the other writers above mentioned.

Most, if not all, of the treatises, to which he thus alludes, must have been extant, and in the hands of his commentators, when they wrote; as appears from their quotations of them; more especially those of Brahmagupta and Āryabhaṭa, who are cited, and particularly the first mentioned, in several instances. A long and diligent research in various parts of India, has, however, failed of recovering any part of the *Padmanābha Bīja* (or the algebra of Padmanābha) and of the algebraic and other works of Āryabhaṭa.

But the translator has been more fortunate in regard to the works of Śrīdhara and Brahmagupta, having in his collection Śrīdhara's compendium of arithmetic, and a copy incomplete however, of the text and scholia of Brahmagupta's *Brahmasiddhānta* comprising among other no less interesting matter, a chapter treating of arithmetic and mensuration; and another, the subject of which is algebra : both of them fortunately complete. The commentary is a perpetual one; successively quoting in length each verse of the text; procceeding to the interpretation of it, word by word; and subjoining elucidations and remarks; and its colophon, at the close of each chapter, gives the title of the work and the name of the author. Now the name which is there given, Caturveda Pṛthūdaka Svāmī, is that of a celebrated scholiast of Brahmagupta, frequently cited as such by the commentaries of

Bhāskara and by other astronomical writers; and the title of the work, *Brāhmasiddhānta* or sometimes *Brāhmasphuṭasiddhānta*, corresponds, in the shorter form, to the known title of Brahmagupta's treatise in the usual references to it by Bhāskara's commentators, and answers, in the longer form, to the designation of it, as indicated in an introductory couplet which is quoted from Brahmagupta by Lakṣmīdāsa, a scholiast of Bhāskara II. Remarking this coincidence, the translator proceeded to collate, with the text and commentary, numerous quotations from both, which he found in Bhāskara's writings or in those of his expositors. The result confirmed the indication and established the identity of both text and scholia as Brahmagupta's treatise, and the gloss of Pṛthūdaka. The authenticity of the *Brāhmasiddhānta* is further confirmed by numerous quotations in the commentary of Bhaṭṭotpala on the *Saṁhitā* of Varāhamihira : as the quotations from the *Brāhmasiddhānta*, in that commentary, (which is the work of an author who flourished eight hundred and fifty years ago) are verified in the copy under consideration. A few instances of both will suffice, and cannot fail to produce conviction.

It is confidently concluded, that the chapters on arithmetic and algebra, fortunately entire in a copy in many parts imperfect, of Brahmagupta's celebrated work as here described, are genuine and authentic. It remains to investigate the age of the author.

Mr. Davis, who first opined to the public a correct view of the astronomical computations of the Hindus, is of opinion, that Brahmagupta lived in the seventh century of the Christian era. Dr. William Hunter, who resided for some time with a British Embassy at Ujjayinī, and made diligent researches into the remains of Indian science at that ancient seat of Hindu astronomical knowledge, was there furnished, by the learned astronomers whom he consulted, with the ages of the principal ancient authorities. They assigned to Brahmagupta the date of 550 Saka; which answers to A.D.

628. The grounds on which they proceeded are unfortunately not specified: but as they gave Bhāskara's age correctly, as well as several other dates right, which admit of being verified; it is presumed that they had grounds, though unexplained, for the information which they communicated.

Mr. Bentley, who is little disposed to favour the antiquity of an Indian astronomer, has given his reasons for considering the astronomical system which Brahmagupta teaches, to be between twelve and thirteen hundred years old (1263 years in A.D. 1799). Now as the system taught by this author is professedly one corrected and adapted by him to conform with the observed positions of the celestial objects when he wrote, the age, when their positions would be conformable with the results of computations made as by him directed, is precisely the age of the author himself: and so far as Mr. Bentley's calculations may be considered to approximate the truth, the date of Brahmagupta's performance is determined with like approach to exactness, within a certain latitude however of uncertainty for allowance to be made on account of the inaccuracy of Hindu observations.

The translator has assigned on former occasions the grounds upon which he sees reason to place the author's age, soon after the period when the vernal equinox coincided with the beginning of the lunar mansion and zodiacal asterism *Aśvinī*, where the Hindu ecliptic now commences. He is supported in it by the sentiments of Bhāskara and other Indian astronomers, who infer from Brahmagupta's doctrine concerning the solistitial points, of which he does not admit a periodical motion, that he lived when the equinoxes did not, sensibly to him, deviate from the beginning of *Aśvinī* and middle of *citrā* on the Hindu sphere. On these grounds it is maintained, that Brahmagupta is rightly placed in the sixth or beginning of the seventh century of the Christian era, as the subjoined calculations will more particularly show. The age when Brahmagupta

flourished, seems then, from the concurrence of all these arguments, to be satisfactorily settled as antecedent to the earliest dawn of the culture of sciences among the Arabs; and *consequently establishes* the fact, that *the Hindus were in possession of algebra before* it was known to the Arabians.

Brahmagupta's treatise, however, is not the earliest work known to have been written on the same subject by an Indian author. The most eminent scholiast of Bhāskara II (Gaṇeśa) quotes a passage of Āryabhaṭa specifying algebra under the designation of *Bīja*, and making separate mention of *Kuṭṭaka*, which more particularly intends a problem subservient to the general method of resolution of indeterminate problems of the first degree : he is understood by another of Bhāskara's commentators to be at the head of the elder writers, to whom the text then under consideration adverts, as having designated by the name of *Madhyamāharaṇa* the resolution of affected quadratic equations by means of the completion of the square. It is to be presumed, therefore, that the treatise of Āryabhaṭa then extant, did extend to quadratic equations in the determinate analysis, and to indeterminate problems of the first degree; if not to those of the second likewise, as most probably it did.

This ancient astronomer and algebraist, so says Colebrooke, was anterior to both Varāhamihira and Brahmagupta, being repeatedly named by the latter; and the determination of the age when he flourished is particularly interesting as his astronomical system, though on some points agreeing, essentially disagreed on others, with that which the Hindu astronomers still maintain.

He, as Colebrooke says, is considered by the commentators of the *Sūryasiddhānta* and *Śiromaṇi*, as the earliest of uninspired and mere human writers on the science of astronomy, as having introduced requisite corrections into the system of Parāśara, from whom he took the numbers for the planetary mean motions; as

having been followed in the tract of emendation, after a sufficient interval to make further correction requisite, by Durgāsinha and Mihira; who were again succeeded after a further interval by Brahmagupta, son of Jiṣṇu.

In short, says Colebrooke, Āryabhaṭa was founder of one of the sets of Indian astronomers, as Puliśa, an author likewise anterior to both Varāhamihira and Brahmagupta, was of another : which were distinguished by names derived from the discriminative tenets respecting the commencement of planetary motions at sunrise according to the first, but at midnight according to the latter, on the meridian of Laṅkā, at the beginning of the great astronomical cycle. A third sect began the astronomical day, as well as the great period, at noon.

Āryabhaṭa's name accompanied the intimation which the Arab astronomers (under the Abbasside Khalifs, as it would appear,) received, that three distinct astronomical systems were current among the Hindus of those days : and it is but slightly corrupted, certainly not at all disguised, in the Arabic representation of it *Arjabahar*, or rather *Arjabhar*, (corrupted form of Āryabhaṭa). The two other systems were, first, Brahmagupta's *Siddhānta* which was the one they became best acquainted with, and to which they apply the denomination of the *sind-hind*; and second, that of *Arca*, the Sun, which they write *Arcand* a corruption still prevalent in the vulgar Hindi.

Āryabhaṭa appears to have had more correct notions of the true explanation of celestial phenomena than Brahmagupta himself, so says Colebrooke; who in a few instances, correcting errors of his predecessor, but oftener deviating from that predecessor's juster views, has been followed by the herd of modern Hindu astronomers, in a system not improved, but deteriorated, since the time of the more ancient author.

Considering the proficiency of Āryabhaṭa in astronomical science, and adverting to the fact of his having

written algebra, as well as to the circumstance of his being named by numerous writers as the founder of a sect, or author of a system in astronomy, and being quotcd at the head of algebraists, when the commentators of extant treatises have occasion to mention early and original writers on this branch of science, it is not necessary to seek further for a mathematician qualified to have been the great improver of the analytic art, and likely to have been the person by whom it was carried to the pitch to which it is found to have attained among the Hindus, and at which it is observed to be nearly stationary through the long lapse of ages which have since passed : the later additions being few and unessential in the writings of Brahmagupta, of Bhāskara and of Jñānarāja, though they lived at intervals of centuries from each other.

Āryabhaṭa, Colebrooke rightly says, then being the earliest author known to have treated of Algebra among the Hindus, and being likely to be, if not the inventor, the improver of that analysis, by whom too it was pushed nearly to the whole degree of excellence which it is found to have attained among them; it becomes in an especial manner interesting to investigate any discoverable trace in the absence of better and more direct evidence, which may tend to fix the date of his labours; or to indicate the time which elapsed between him and Brahmagupta, whose age is more accurately determined.

Taking Āryabhaṭa, for reasons given, to have preceded Brahmagupta and Varāhamihira by several centuries; and Brahmagupta to have flourished more than twelve hundred years ago, and Varāhamihira, concerning whose works and age, Colebrooke has given a few notes, and has placed him at the beginning of the sixth century after Christ, it appears probable that this earliest of known Hindu algebraists wrote as far back as the fifth century of the Christian era; and perhaps in an earlier age. Hence it is concluded that he is nearly as ancient as the Greecian algebraist Diophantus, sup-

posed on the authority of Abulfaraj, to have flourished in the time of the Emperor Julian or about A. D. 360.

Colebrooke further says : Admitting the Hindu and Alexandrian authors to be nearly equally ancient, it must be conceded in favour of the Indian algebraist, that he was more advanced in the science; since he appears to have been in possession of the resolution of equations involving several unknowns, which it is not clear, nor fairly presumable, that Diophantus, knew; and a general method of indeterminate problems of at least the first degree, to a knowledge of which the Greecian algebraist had certainly not attained ; though he displays infinite sagacity and ingenuity in particular solutions ; and though a certain routine is indiscernible in them.

Colebrooke appears to be of the view that Greeks were the first to discover the solution of equations involving one unknown; and this knowledge was passed to ancient Indians by their Greek instructors in improved astronomy. But "by the ingenuity of the Hindu-scholars, the hint was rendered fruitful and the algebraic method was soon ripened from that slender beginning to the advanced state of a well arranged science, as it was taught by Āryabhaṭa, and as it is found in treatises compiled by Brahmagupta and Bhāskara."

We do not agree with this analysis in entirety. Indian algebra is entirely of Indian roots. It had its beginning in the times of Saṃhitās and Brāhmaṇas. Some of the equations and problems were solved by geometric methods. It must have had its origin in the Śulba period if not before. Āryabhaṭa undoubtedly was the discoverer of many algebraic solutions of equations of the first and higher order with one and more unknowns. It is rather too much to trace the influence of Diophantus on Indian algebra which developed in this country independently. Brahmagupta is one of the most brilliant algebraists we ever had in the entire history of mathematics.

Technical Terms

Coefficient—

In the ancient Indian algebra, there is no systematic term for the coefficient. Usually, the power of the unknown is mentioned when the reference is to the coefficient of that power. At one place, for example, we find Pṛthūdaka Svāmī (the commentator of Brahmagupta's *Brāhmasphūṭasiddhānta*) writing "the number (*aṅka*) which is the coefficient of the square of the unknown is called the '*square*' and the number which forms the coefficient of the (simple) unknown is called the 'unknown quantity' (*avyakta-māna*)."[1] However, at many places, we find the use of a technical term also. Brahmagupta once calls the coefficient *saṁkhyā*[2] (number) and on several other occasions *guṇaka*[3] or *guṇakāra*[4] (multiplier). Pṛtthūdaka Svāmī (860 A.D.) calls it *aṅka* (number) or *prakṛti* (multiplier). These terms may also be seen in the works of Śrīpati[6] (1039) and Bhāskara II[7] (1150 A.D.), The former also used the word *rūpa* for the same purpose.[8]

Unknown Quantity

The unknown quantity has been termed as *yāvat-tāvat* (meaning so-much-as or as-many-as) in literature as early as 300 B. C. (vide the *Sthānāṅga-sūtra*[9]). In the *Bakhaśālī Manuscript*, it has been termed as *yadṛcchā*. *vāñchā* or *kāmikā* (or any desired quantity)[10]. Āryabhaṭa I in one of his verses calls the unknown as *gulikā*[11] (literally meaning a shot) From the early seventh century A.D., the word *avyakta* was used for unknown quantities. Brahmagupta uses this term in his *Brāhmasphuṭasiddhānta*[12]

1. *BrSpSi. XVIII*. 44 (Com.)
2. वर्णप्रमाण भावितघातो भवतीष्ट वर्णं संख्यैवम् । —*BrSpSi. XVIII* 63
3. मूलं द्विघेष्ट वर्गाद् गुणक गुणादिष्ट युत विहीनाच्च । —*BrSpSi. XVIII* 64
वर्गच्छिन्ने गुणके प्रथमं तन्मूल भाजितं भवति । —*BrSpSi. XVIII* 70
4. प्रथमोन्यमूलमन्यो गुणकार पदोद्धृतः प्रथमः । —*BrSpSi. XVIII* 69
5. *BrSpSi XVIII*. 44 (Com.)
6. *Siśe XIV*. 33-5.
7. *Bījagaṇita*
8. *Siśe XIV*. 33-5.
9. *Sūtra* 747.
10. *BMs*. Folio 22, verso; 23, recto and verso,
11. गुलिकान्तरेण विभजेद् द्वयोः ।
12. अव्यक्तवर्गं घनवर्गं वर्गपंचगत षड्गतादीनाम् ।

Power

Since long, the word *varga* has been used for the second power; the word also stands for *square* (*Uttarādhyayana Sūtra*[1], B. C. c. 300). The third power is similarly known as *ghana*, the fourth power as *varga-varga* (square-square), the sixth power as *ghana-varga* (cube-square) and the twelfth power as *ghana-varga-varga* (cube-square-square). In later days, the fifth power was called *vargaghana ghāta* (here the word *ghāta* means product; the term means product of cube and square). The former system was multiplicative, rather than additive; wheras the latter was on the additive system. The seventh power on the additive system was known as *varga-varga-ghana-ghāta* (product of square-square and cube). Brahmagupta, however, uses a more scientific system for expressing the powers more than four. He calls the fifth power as *Pañca gata* (literally meaning, raised to the fifth), the sixth power as *ṣaḍ-gat* (raised to the sixth) and so on, thus adding the suffix *gata* to the name of the number indicating that power.[2] Bhāskara II has followed the system of Brahmagupta almost consistently for powers one and upwards.

Equation

Perhaps Brahmagupta has for the first time used the term *samakaraṇa* or *samīkaraṇa* (literally meaning making equal) or simply *sama* (equal or equation)[3]. Pṛthūdaka Svāmī (860) employs the term *sāmya* (equality or equation) for equation[4]. The equation is said to possess two *Pakṣas*[5] (sides) *Itara-Pakṣa* and *apara-pakṣa*.

Absolute Term

Brahmagupta uses the term *rūpa* (literally meaning appearance) for an absolute term. It represents the visible or known

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1. Chapter XXX, 10. 11.
2. अव्यक्तवर्ग घनवर्ग-वर्ग-पंचगत-षड्गतादीनाम् ।
   सदृश द्विवधो वर्गस्त्र्यादि वधस्तद्गतोऽन्य जातिवधः ॥
3. वर्ण प्रमाण भावित-घातो भवतीष्टवर्ण संख्यैवम् ।
   सिध्यति विनाऽपि भावित-समकरणात् किं कृतं तद्गतः ॥
   अव्यक्तान्तर भक्तं व्यस्तं रूपान्तरं समेऽव्यक्तः ।
4. *Sise*. XIV. 19.
5. *Bījagaṇita*.

portion of the equation whilst its other part is practically invisible or unknown[1].

Unknowns and Symbolism

Āryabhaṭa I (499 A. D.) probably used coloured *gulikās* or shots for represtnting different unknowns. Brahmagupta mentions *varṇa* as the symobls for unknown. He has, however, not indicated how these *varṇas* or colours were used as symbols for unknowns. Perhaps we might conculude from this that the method of using colours as symbols for unknown quantities was very common and familiar to the algehraists. Datta and Singh say that the Sanskrit word *varṇa* denotes colour as well as a letter of alphabet, and therefore, letters of alphabet came into use for unknown quantities : *kālaka* (black), *nīlaka* (blue), *pītaka* (yellow), *lohita* (red), *harītaka* (green), *śvetaka* (white), *citraka* (variegated), *kapilaka* (tawny), *piṅgalaka* (reddish-brown), *dhūmraka* (smoke-coloured), *pāṭalaka* (pink). *śavalaka* (spotted), *śyāmalaka* (blackish) *mecaka* (dark blue) etc[2].

It should be further noted that the first unknown quantity *yāvat-tāvat* is not a *varṇa* or colour. It thus clearly indicates that the use of colours as symbols came at a later stage, whilst the word *yāvat-tāvat* was in currency from much earlier times. Some authorities think that the term *yāvat-tāvat* is a corrupted form of *yāvakastāvat* (where *yāvaka* means red). Pṛthūdaka Svāmī has sometimes used the term *yavaka* for an unknown quantity[3].

Laws of Signs

Brahmagupta has in his Chaper XVIII devoted a special section entitled "*Dhanarṇa Śunyānām Samkalanam*" or calculations dealing with quantities bearing positive and negative signs and zero,

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1. अव्यक्तान्तरं भक्तं व्यस्तं रूपान्तरं समेऽव्यक्तः । —*BrSpSi* XVIII. 43
वर्गं चतुर्गुणितानां रूपाणां मध्यवर्गं सहितानाम् ॥ —*BrSpSi* XVIII. 44

2. यावत्-तावत् कालको नीलकोऽन्यो वर्णः पीतो लोहितश्चैतदाद्याः ।
अव्यक्तानां कल्पिता मानसंज्ञास्तत्संख्यानं कर्तुमाचार्यवर्यैः ॥
यावत्-तावत् कालक नीलक पीतास्च लोहितो हरितः ।
श्वेतक चित्रक कपिलक पाटलकाः पण्डु धूम्र शवलास्च ॥
श्यामलक-मेचक-धवलक-पिशङ्ग-शारङ्ग-बभ्रु गौराद्याः । —Nārāyaṇa, *Bījagaṇita*

3. *BrSpSi XII. 15.* (Com.) ; XII 18.

Regarding *addition*, Brahmagupta says :

> The sum of two positive numbers is positive, of two negative numbers is negative; of a positive and negative number is the difference[1].

Regarding *subtraction*, Brahmagupta further says :

> From the greater should be subtracted the smaller; (the final result is) positive, if positive from positive, and negative, if negative, from negative. If, however, the greater is subtracted from the less, that difference is reversed (in sign), negative becomes positive and positive becomes negative. When positive is to be subtracted from negative or negative from positive, then they must be added together[2].

Mahāvīra (850 A. D.), Bhāskara II (1150 A.D.) and Nārāyaṇa (1350 A. D.) have also given similar rules regarding addition (*Saṁkalanam*) and the subtraction (*vyavakalanam*).

Again, the rule given by Brahmagupta regarding *Multiplication* is as follows :

> The product of a positive and a negative (number) is negative; of two negatives is positive; positive multiplied by positive is positive[3].

His rule regarding *division* is as follows ;

> Positive divided by positive or negative divided by negative becomes positive. But positive divided by negative and negative divided by positive remains negative[4].

Similar rules for multiplication and division were provided by later authorities as Mahāvīra and Bhāskara II.

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1. *BrSpSi XII. 15. (Com.); XII 18. (Com.)*
2. धनयोर्धनमृणमृणयोर्धनर्णयोरन्तरं समैक्यं खम् ।
   ऋणमैक्यं च धनमृणधन शून्ययोः शून्ययोः शून्यम् ॥ —*BrSpSi*. XVIII-30
3. ऊनमधिकाद्विशोध्यं धनं धनादृणमृणादधिकमूनात् ।
   व्यस्तं तदन्तरं स्यादृणं धनं धनमृणं भवति ॥
   शून्यविहीनमृणमृणं धनं धनं भवति शून्यमाकाशम् ।
   शोध्यं यदा धनमृणादृणं धनाद्वा तदा क्षेप्यम् ॥ —*BrSpSi* XVIII. 31-32
4. ऋणमृणधनयोर्घातो धनमृणयोर्धनवधो धनं भवति ।
   शून्यर्णयोः ख धनयोः ख शून्ययोर्वा वधः शून्यम् ॥ —*BrSpSi* XVIII. 33
5. धनभक्तं धनमृणहृतमृणं धनं भवति खं खभक्तं खम् ।
   भक्तमृणेन धनमृणं धनेन हृतमृणमृणं भवति ॥ —*BrSpSi*. XVIII. 34

Brahmagupta lays down the rules regarding *evolution* and *involution* as follows :

> The square of a positive or a negative number is positive .....The (sign of the) root is the same, as was that from which the square was derived[1].

As regards the latter portion of this rule, Pṛthūdaka Svāmī has the following comment to make : "The square-root should be taken either negative or positive, as will be most suitable for subsequent operations to be carried on."

It will be interesting to observe the following observation of Mahāvīra (850 A. D.) regarding square-root of a negative quantity "Since a negative number by its own nature is not a square, it has no square-root."[2] So says Śrīpati : "A negative number by itself is non-square, so its square-root is unreal; so the rule (for the square-root) should be applied in the case of a positive number."[3]

Algebraic Operations

Brahmagupta and other algebraists recognise six operations as fundamental in algebra : addition, subtraction, multiplication, division, squaring and the extraction of the square-root.

Regarding *addition* and *subtraction* Brahmagupta says:

> Of the unknowns, their squares, cubes, fourth powers, fifth powers, sixth powers, etc., addition and subtraction are (performed) of the like; of the unlike (they mean simply their) statement severally.[4]

In place of "of the like", Bhāskara II uses the term "of those of the same species (*jāti*) amongst unknowns" :

> Addition and subtraction are performed of those of the same species (*jāti*) amongst unknowns; of different species they mean their separate statement.[5]

1. खोद्धृत मृणं धनं वा तच्छेदं खमृणधनविभक्तं वा ।
ऋणधनयोर्वर्गः स्वं खं खस्य पदं कृतिर्यत् तत् ॥ —*BrSpSi*, XVIII. 35
2. GSS. I. 52.
3. *Śiśe*. XIV. 5.
4. अव्यक्तवर्ग घनवर्ग वर्ग पंचगत षड्गतादीनाम् ।
तुल्यानां संकलित व्यवकलिते पृथगतुल्यानाम् ॥ —*BrSpSi.XVIII. 41.*
5. योगोऽन्तरं तेषु समान जात्योर्विभिन्न जात्योश्च पृथक् स्थितिश्च ।
— *Bhāskara* II, *Bījagaṇita.*

This means that the numerical coefficients of x cannot be added to or subtracted from the numerical coefficients of y or x^2 or x^3 or xy and so on because these terms belong to different *jāti* or they do not belong to the category of the "*like*".

Again, regarding *multiplication*, Brahmagupta says :

> The product of the two like unknowns is a square; the product of three or more like unknowns is a power of that designation. The multiplication of unknowns of unlike species is the same as the mutual product of symbols; it is called *bhāvita* (product or factum).[1]

Having given the rules of the operations for addition, subtraction and multiplication, Brahmagupta does not think it necessary to deal with other operations. His section on the calculations with zero, negative and positive quantities ends here.

How is an Equation Formed?

Pṛthūdaka Svāmī while commenting on a verse in *Brāhma-sphuṭasiddhānta* speaks as follows :

> In this case, in the problem proposed by the questioner, *yāvat-tāvat* is put for the value of the unknown quantity. Then performing multiplication, division etc. as required in the problem the two sides shall be carefully made equal. The equation being formed in this way, then the rule (for its solution) follows.[2]

Plan for Writing Equations

When in regards to a given problem, an equation has been formed, it has to be written down for further operations. This writing down of an equation is technically known as *nyāsa* Perhaps the oldest record of *nyāsa* is to be found in the *Bakhaśālī Manuscript*. According to the procedure prescribed in this work, the two sides of an equation are put down one after the other in the same line without any sign of equality being interposed. Thus the equations :

$$\sqrt{x+5}=s, \quad \sqrt{x-7}=t$$

appear as

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1. सदृशद्विवधो वर्गस्त्र्यादिवधस्तद् गतोऽन्यजातिवधः ।
अन्योऽन्यवर्णघातो भावितकः पूर्ववच्छेषम् ॥ —*BrSpSi*.XVIII. 42.

2. *BrSpSi*. XVIII. 43 (com)

$$\left|\begin{matrix}0 & 5\\ 1 & 1\end{matrix}\ yu\ m\bar{u}\ \begin{matrix}0\\1\end{matrix}\ \right|\ sa\ \begin{matrix}0 & 7\\ 1 & 1\end{matrix}\ +\ m\bar{u}\ \begin{matrix}0\\1\end{matrix}\right|$$

Here *yu* (यु) stands for *yuta* (युत), meaning added, subtraction is+sign, derived from Kṣaya or (क्षय) meaning diminished, *gu* (गु) for guṇa or *guṇita*, meaning multiplied; *bhā* (भा) for division from *bhājita* and *mū* (मू) for square-root, from *mūla* meaning root; *zero* (०) was used to mark a vacant place.

Again, the following equation

$$x+2x+3\times3x+12\times4x=300$$

is represented as ;

$$\left|\begin{matrix}0\\1\end{matrix}\right|\begin{matrix}2 & 1\\1 & 1\end{matrix}\left|\begin{matrix}3 & 3\\1 & 1\end{matrix}\right|\begin{matrix}12 & 4\\1 & 1\end{matrix}\Big| \qquad dṛśya\ 300$$

There is no sign for unknown in the *Bakhaśālī Manuscript.*

Later on this plan of writing equations as adopted in *Bakhaśālī Manuscript* was abandoned in India; a new one was adopted in which the two sides are written one below the other without any sign of equality. It must be stated that in this new plan the term of similar denominations are usually written one below the other and even the terms of absent denominations on either side are clearly indicated by putting zeros as their coefficients. We find a reference to this new plan in the algebra of Brahmagupta.

> From which the square of the unknown and the unknown are cleared, the known quantities are cleared (from the side) *below* that[1].

Here in this verse, the words "*adhastāt*" clearly indicate that one side of the equation is written below the other., As an illustration, Pṛthūdaka Svāmī represented the equation[2] :—

$$10x-8=x^2+1$$

as :

yā va 0 *yā* 10 *rū* $\dot{8}$ $(x^2.0+x.10-8)$

yā va 1 *yā* 0 *rū* 1 $(x^2.1+x.0+1)$

which means, x^2 was written as *yāvat-varga* (*yā va*) and x was written as *yāvat* or *yā*. The minus sign was represented by a dot at the top of the number.(—8 was written as $\dot{8}$). We shall take another illustration from Pṛthūdaka Svāmī.

He would write the equation

$$197x-1644\ y-z=6302$$

as

1. *BrSpSi.* XVII. 43; compare also Bhāskara II, *Bījagaṇita*.
2. *Br SpSi.* XVIII. 49 (*com.*)

yā	197	*kā*	$\dot{1644}$	*nī*	$\dot{1}$	*rū*	0
yā	0	*kā*	0	*nī*	0	*rū*	6302

Here the first unknown x is represented by *yā(vat)*, the second unknown y by *kā(laka)* and the third unknown z by *nī-(laka)* and the term without unknown, a mere number is wrirten by *rū(paka)*. The two sides, one written below the other if written in the present form, would appear as :

$$197x—1644y—z+0=0x+0y+0z+6302.$$

The *Bījagaṇita* of Bhāskara II also follows the same procedure. One instance from it would be quoted here to illustrate the method of expressing equations.

$$8x^3+4x^2+10y^2x=4x^3+12y^2x$$

or $8x^3+4x^2+10y^2x=4x^3+0x^2+12y^2x$

is written as follows on Bhāskara's or Brahmagupta's plan :

x^3 is *ghana* of *yāvat* (abbreviated as *yā gha*)
x^2 is *varga* of *yāvat* (abbreviated as *yā va*)
y^2 is *varga* of *kālaka* (abbreviated as *kā va*)
the coefficients 10 and 12 are *bhāvita* (abbreviated as *bhā*).

The equation is :

yā gha 8 *yā va* 4 *kā va yā. bhā* 10
yā gha 4 *yā va* 0 *kā va yā. bhā* 12

Datta and Singh state that the use of the old plan of writing equations is sometimes met with in later works also. For instance, in the MS. of Pṛthūdaka Svāmī's commentary[1] on the *Brāhmasphuṭasiddhānta*, an incomplete copy of which is preserved in the library of the Asiatic Society of Bengal (No. I B6), we find a statement of equations thus : "first side *yāvargaḥ* 1 *yāvakaḥ* 200 *rū* 0; second side *yāvargaḥ* 0 *yāvakaḥ* 0 *rū* 1500.

Śodhana or Clearancc of an Equation

After *nyāsa* or statement of an equation, the operation to be performed is known as *śodhana* (clearance) or *saṁśodhana* (equi-clearance or complete clearance). The nature of this clearance varies according to the kind of equation In the case of an equation in one unknown only, whether linear,

1. *BrSpSi*. XII. 15 (*com.*)

quadratic or of higher powers, one side of it is cleared of the unknowns of all denominations and the other side of it of the absolute terms, so that the equation is ultimately reduced to one of the form

$$ax^2+bx=c,$$

where a, b, c may be positive or negative; some of them may even be zero. Thus Brahmagupta observes :

> From which the square of the unknown and the unknown are cleared, the known quantities (*rūpāṇi*) are cleared (from the side) *below* that.[1]

On this Pṛthūdaka Svāmi comments as follows :

> This rule has been introduced for that case in which the two sides of the equation having been formed in accordance with the statement of the problem, there are present the square and other powers of the unknown together with the (simple) unknown. The absolute terms should be cleared off from the side opposite to that from which are cleared the square (and other powers) of the unknown and the (simple) unknown. When perfect clearance (*saṁśodhana*) has been thus made...[2]

Śrīdhara and Bhāskara II have also given the rules of clearance almost on the same lines. Thus the equation

yā va 0 *yā* 10 *rū* $\dot{8}$
yā va 1 *yā* 0 *rū* 1

after perfect clearance having been made will be (according to Pṛthūdaka Svāmī)

yā va 1 *yā* 1 $\dot{0}$ *rū* $\dot{9}$

i.e. the equation $10x-8=x^2+1$
after clearance would become

$$x^2-10x=-9.$$

Classification of Equations

Usually equations are classified as :

simple equation : *yāvat-tāvat*
quadratic : *varga*

1. वर्गाव्यक्ताः शोध्या यस्माद् रूपाणि तदधस्तात् ॥ —*BrSpSi.* XVIII. 43.
2. *BrSpSi.* XVIII. 43 (*com.*)

cubic : *ghana*
biquadratic : *varga-varga*

Brahmagupta classified them as

(i) equations in one unknown quantity: *eka-varṇa samīkaraṇa.*

(ii) equations in several unknowns : *aneka-varṇa samīkaraṇa.*

(iii) equations involving products of unknowns: *bhāvita.*

Eka-varṇa samīkaraṇas (equations with one unknown) are further divided into (i) linear equations, and (ii) quadratic equations (*avyakta-varga samīkaraṇa*).

Pṛthūdaka Svāmī has classified equations in a different manner as follows :

(i) linear equations with one unknown : *eka-varṇa samīkaraṇa.*

(ii) linear equations with more unknowns : *aneka-varṇa samīkaraṇa.*

(iii) equations with one, two or more unknowns in their second or higher powers : *madhyamāharaṇa.*

(iv) equations involving products of unknowns : *bhāvita.*

As the method of solution of an equation of the third class (i.e. equations with one or several unknowns in their second or higher powers) is based upon the principle of the elimination of the middle term, that class is called by the term *madhyama* (middle) *āharaṇa* (elimination). The classification of Brahmagupta and Pṛthūdaka Svāmī more or less received recognition by later writers on algebra as Bhāskara II and others.

Linear Equations with One Unknown and Their Solutions

The first solution of a linear equation with one unknown is obtainable in the *Śulba Sūtras* but not through an algebraic process,—the Śulba process is geometrical. It is said that there is a reference in the *Sthānāṅga Sūtra* (c. 300 B.C.) to a linear equation by its name *yāvat-tāvat*. There has been a good deal of

controversy regarding the date of the *Bakhaśalī Manuscript* where we have definitely a method of solving linear equations by the *Rule of False Position*. It would be interesting to give an account of this rule here by taking an illustration from the *Bakhaśālī Manuscript.*

Problem :

> The amount given to the first is not known. The second is given twice as much as the first; the third thrice as much as the second; and the fourth four times as much as the third. The total amount distributed is 132. What is the amount of the first ?
>
> (*BMS*. Folio 23, recto)

In modern algebraic language, the solution of the problem would be given by the equation

$$x+2x+6x+24x=132$$

where x is the amount given to the first.

The solution of this equation is given as follows in the *Bakhaśālī Manuscript* :

> 'Putting any desired quantity in the vacant place'; any desired quantity is ‖ 1 ‖, 'then construct the series'
>
> $\left|\ \frac{1}{1}\ \middle|\ \frac{2}{1}\ \middle|\ \frac{2}{1}\ \middle|\ \frac{3}{1}\ \middle|\ \frac{6}{1}\ \middle|\ \frac{4}{1}\ \right|$
>
> 'multiplied' ‖ 1 | 2 | 6 | 24 | ; 'added' 33. 'Divide the visible quantity' $\left|\ \frac{132}{33}\ \right|$; which) on reduction becomes $\left|\ \frac{4}{1}\ \right|$. (This is) the amount given (to the first)
>
> (*BMS*. Folio 23, recto)

The Rule of False Position may be regarded as an early stage of the development of the science of algebra, since no symbol could have been evolved for an unknown quantity. As soon as the system of notations was introduced, the application of this Rule was no longer considered as necessary. Thus we find that Āryabhaṭa I does not mention of this Rule.

Āryabhaṭa I states as follows regarding the solution of linear equations :

> The difference of the known 'amounts' (*rūpaka*) relating to two persons should be divided by the difference

> of the coefficients on the unknown (*gulikā*). The quotient will be the value of the unknown (*gulikā*), if their possessions be equal.[1]

The original verse contains the term "*gulikāntara*" which has been here translated as the difference of the coefficients of the unknowns. We have already stated earlier that Āryabhaṭa uses the term *gulikā* or shot for an unknown quantity.(*gulikāntara* literally means only the difference of unknowns). This practice is also followed by other Indian algebraists. Pṛthūdaka Svāmī rightly observed that according to the usual practice in this country, "the coefficient of the square of the unknown is called the square (of the unknown) and the coefficient of the (simple) unknown is called the unknown.[2]

The rule given by Āryabhaṭa, then, contemplates a problem of this kind :

> Two persons, who are equally rich, possess respectively a, b times a certain unknown amount together with c, d units of money in cash. What is that amount ?

Now if x be the amount unknown, then according to the problem

$$ax+c=bx+d$$

Thence

$$x=\frac{d-c}{a-b}$$

Āryabhaṭa has merely expressed this solution in his language.

Regarding the solution of linear equations, Brahmagupta says :

> In a (linear) equation in one unknown, the difference of the known terms taken in the reverse order, divided by the difference of the coefficients of the unknown (is the value of the unknown).[3]

---

1. गुलिकान्तरेण विभजेद् द्वयोः पुरुषयोस्तु रूपकविशेषम् ।
लब्धं गुणिकामूल्यं यद्यर्थं कृतं भवति तुल्यम् ॥ —*Ārya*. II. 30

2. *BrSpSi*, XVIII. 44 (*com.*)

3. अव्यक्तान्तरभक्तं व्यस्तं रूपान्तरं समेऽव्यक्तः ।
वर्गाव्यक्ताः शोध्या यस्माद् रूपाणि तदधस्तात् ॥ —*BrSpSi*. XVIII. 43

Similar solutions have been offered by the other Indian algebraists who followed Brahmagupta like Śrīpati, Bhāskara II and Nārāyaṇa. Here again, we take a problem proposed by Brahmagupta in this connection :

Problem :

> Tell the number of elapsed days for the time when four times the twelfth part of the residual degrees increased by one, plus eight will be equal to the residual degrees plus one.[1]

Pṛthūdaka Svāmī has solved this problem as follows :

Here the residual degrees are (put as) *yāvat-tāvat*, *yā*; increased by one, *yā* 1 *rū* 1; twelfth part of it, $\frac{yā\ 1\ rū\ 1}{12}$; four times this, $\frac{yā\ 1\ \ rū\ 1}{3}$; plus the absolute quantity eight, $\frac{yā\ 1\ \ rū\ 25}{3}$. This is equal to the residual degrees plus unity. The statement of both sides tripled is

yā 1   *rū* 25
yā 3   *rū* 3

This difference between the coefficients of the unknown is 2. By this the difference of the absolute terms, namely 22, being divided, is produced the residual of the degrees of the Sun, 11. These residual degrees should be known to be irreducible. The elapsed days can be deduced then, (proceeding) as before.

If put in the modern notations, it means the solution of the equation :

$$\frac{4}{12}(x+1)+8=x+1,$$

from which we have

$$x+25=3x+3$$

or $$2x=22$$

or $$x=11.$$

Rule of Concurrence or Saṁkramaṇa

Brahmagupta has included this rule in algebra, whereas other Indian mathematicians included it in arithmetic. *Saṁ-*

1. सैकादंशकशेषाद् द्वादशभागश्चतुर्गुणोऽष्टयुतः ।
सैकांशशेषतुल्यो यदा तदाऽहर्गणं कथय ॥ —*BrSpSi. XVIII.* 46

kramaṇa is the solution of the simultaneous equations of the type :

$$x+y=a$$
$$x-y=b$$

Brahmagupta's rule for solution is:

> The sum is increased and diminished by the difference and divided by two; (the result will be the two unknown quantities) : (this is) concurrence (*Saṁkramaṇa*).[1]

Brahmagupta restates this rule in the form of a problem and its solution :

> The sum and difference of the residues of two (heavenly bodies) are known in degrees and minutes. What are the residues? The difference is both added to and subtracted from the sum, and halved; (the results are) the residues.[2]

Linear Equations with Several Unknowns

The first mention of a solution of the problem with more than one unknown is found in the *Bakhaśālī Manuscript*, and a system of linear equations of this type is solved in the Bakhaśālī treatise substantially by the False Position Rule.

A generalised system of linear equations will be

$$b_1\Sigma x-c_1x_1=a_1,\ b_2\Sigma x-c_2x_2=a_2,\ldots\ldots,$$
$$b_n\Sigma x-c_nx=a_n$$

Therefore

$$\Sigma x=\frac{\Sigma(a/c)}{\Sigma(b/c)-1}$$

Hence

$$x_r=\frac{b_r}{c_r}\times\frac{\Sigma(a/c)}{\Sigma(b/c)-1}-\frac{a_r}{c_r}$$
$$r=1, 2, 3,\ldots\ldots, n$$

One particular case, where $b_1=b_2=b_3=\ldots\ldots=b_n=1$ and $c_1=c_2=c_3=\ldots\ldots=c_n=c$ has been treated by Brahmagupta at one place. He gives the rule as follows :

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1. योगोऽन्तरयुतहीनो द्विहृतः संक्रमणमन्तरविभक्तं वा ।
   वर्गान्तरमन्तरयुतहीनं द्विहृतं विषमकर्म ।। —*BrSpSi. XVIII. 36*
2. भागकला विकलैक्यं दृष्ट्वा विकलान्तरं च के शेषे ।
   ऐक्यं द्विधाऽन्तराधिक हीनं च द्विभाजितं शेषे ।। —*BrSpSi. XVIII. 96*

The total value (of the unknown quantities) plus or minus the individual values (of the unknowns) multiplied by an optional number deing severally (given), the sum (of the given quantities) divided by the number of unknowns increased or decreased by the multiplier will be the total value; thence the rest (can be determined).[1]

$$\Sigma x \pm c x_1 = a_1,\ \Sigma x \pm c x_2 = a_2,\ \Sigma x \pm c x_3 = a_3, \ldots\ldots,$$
$$\Sigma x \pm c x \ = a_n$$

Therefore

$$\Sigma x = \frac{a_1 + a_2 + a_3 + \ldots\ldots + a_n}{n \pm c}$$

Hence

$$x_1 = \frac{1}{c}\left(\pm a_1 \mp \frac{a_1 + a_2 + a_3 + \ldots\ldots + a_n}{n \pm c} \right);$$

and so on for x_2, x_3 etc.

Now we shall give the rule enunciated by Brahmagupta for solving linear equations involving several unknowns :

> Removing the other unknowns from (the side of) the first unknown and dividing by the coefficient of the first unknown, the value of the first unknown (is obtained). In the case of more (values of the first unknown), two and two (of them) should be considered after reducing them to comon denominators. And (so on) repeatedly. If more unknowns remain (in the final equation), the method of the pulveriser (should be employed). (Then proceeding) reversely (the values of other unknowns can be found).[2]

Pṛthūdaka Svāmī has commented on this rule as follows :

> In an example in which there are two or more unknown quantities, colours such as *yāvat-tāvat*, etc., should be assumed for their values. Upon them should

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1. गच्छधनमिष्ट गुणितैर्धनैर्युतोनं पृथक् पृथक् सहितम् ।
गुणकयुतोन पदहृतं सर्वधनमतोऽवशेषाणि ॥ —*BrSpSi.* XIII. 47

2. आद्याद्वर्णादन्यान् वर्णान् प्रोह्याद्यमानमाद्यहृतम् ।
सदृशच्छेदावसकृद् द्वौ व्यस्तौ कुट्टको बहुषु ॥ —*BrSpSi.* XVIII. 51

> be performed all operations conformably to the statement of the example and thus should be carefully framed two or more sides and also equations. Equi-clearance should be made first between two and two of them and so on to the last: from one side one unknown should be cleared, other unknowns reduced to a common denominator and also the absolute numbers should be cleared from the side opposite. The residue of other unknowns being divided by the residual coefficient of the first unknown will give the value of the first unknown. If there be obtained several such values, then with two and two of them, equations should be formed after reduction to common denominators. Proceeding in this way to the end find out the value of one unknown. If that value be (in terms of) another unknown then the coefficients of those two will be reciprocally the values of the two unknowns. If, however, there be present more unknowns in that value, the method of the pulveriser should be employed. Arbitrary values may then be assumed for some of the unknowns.

Datta and Singh have said that the above rule of Brahmagupta, and also the one indicated in the commentary of Pṛthūdaka Svāmī, embraces the solution of indeterminate as well as the determinate equations. In fact, all the examples given by Brahmagupta in illustration of the rule are of indeterminate character. So far as the determinate simultaneous equations are concerned, Brahmagupta's method for solving them will be easily recognised to be the same as our present one.

Quadratic Equations

The geometrical solution of a quadratic equation in this country would take us to the Vedic Śulba period. The *Bakhaśālī Manuscript* also contains certain problems which need the solving of quadratic equations. I shall quote one out of the numerous available:

> A certain person travels s *yojana* on the first day and b *yojana* more on each successive day. Another who travels at the uniform rate of S *yojana* per day, has a start of t days. When will the first man overtake the second ?

This problem would today be expressed in terms of the following equation :

$$S(t+x)=x\left\{s+\left(\frac{x-1}{2}\right)b\right\},$$

where x is the number of days after which the first overtakes the second. We may write this equation as

$$bx^2-\{2(S-s)+b\}x=2tS$$

whence the value x would be after solving the quadratic :

$$x=\frac{\sqrt{\{2(S-s)+b\}^2+8bts}+\{2(S-s)+b\}}{2b}$$

The *Bakhaśālī Manuscript* gives this solution as follows :

> The daily travel (S) diminished by the march of the first day (s) is doubled; this is increased by the common increment (b). That (*sum*) multiplied by itself is designated (as the *kṣepa* quantity). The product of the daily travel and the start (t) being multiplied by eight times the common increment, the *kṣepa* quantity is added. The square-root of this (is increased by the *kṣepā* quantity; the sum divided by twice the common increment will give the required number of days), (*BMS*. Folio 5, recto)

Āryabhaṭa I (499 A.D.) is regarded as the founder of algebra, since he gives the solutions of a few quandratic problems. For example, to find the number of terms of an arithmetical progression (A.P.), he gives the following rule :

> The sum of the series multiplied by eight times the common difference is added by the square of the difference between twice the first term and the common difference: the square-root (of the result) is diminished by twice the first term and (then) divided by the common difference : half of this quotient plus unity is the number of terms.[1]

In the modern notations of algebra, the solution would be expressed as follows :

---

1. गच्छोऽष्टोत्तर गुणिताद् द्विगुणाद्युत्तर विशेषवर्गयुतात् ।
मूलं द्विगुणाद्यूनं स्वोत्तर भजितं सरूपार्धं ॥ —*Ārya*. II, 20

$$n=\frac{1}{2}\left\{\frac{\sqrt{8bs+(2a-b)^2}-2a}{b}+1\right\}$$

There is another certain interest problem[1], the solution of which has been provided in the *Āryabhaṭīya* as

$$x=\frac{\sqrt{Apt+(p/2)^2}-p/2}{t}$$

which is the solution of the quadratic equation :

$$tx^2+px-Ap=0$$

Āyabhaṭa I has thus given the solutions of a few quadratic equations, but he nowhere gives the procedure of solving these equations.

We give here the Rules of Brahmagupta for the solution of quadratic equations. He undoubtedly is not the discoverer of these rules; but perhaps for the first time in the history of algebra we find the process of solving a quadratic equation so clearly indicated.

First Rule :

> The quadratic : the absolute quantities multiplied by four times the coefficient of the square of the unknown are increased by the square of the coefficient of the middle (i.e. unknown); the square-root of the result being diminished by the coefficient of the middle and divided by twice the coefficient of the square of the unknown, is (the value of) the middle."[2]

This expressed in the modern notations would mean

$$x=\frac{\sqrt{4ac+b^2}-b}{2a}$$

It would be noted that in this rule, Brahmagupta has employed the term *madhya* (middle) to imply the simple unknown as well as its coefficient. The origin of the term is doubtless connected with the mode of writing the quadratic equation in the form

$$ax^2+bx+0=0x^2+0x+c$$

so that there are three terms on each side of the equation.

---

1. मूलफलं सफलं कालमूल गुणमर्धमूल कृति युक्तम् ।
मूलं मूलार्धोनं कालहृतं स्यात्स्वमूलफलम् ।। —*Ārya. II. 25.*

2. वर्गं चतुर्गुणितानां रूपाणां मध्यवर्गसहितानाम् ।
मूलं मध्येनोनं वर्गं द्विगुणोद्धृतं मध्यः ॥ —*BrSpSi.* XVIII. 44.

Second Rule :

> The absolute term multiplied by the coefficient of the square of the unknown is increased by the square of half the coefficient of the unknown; the square-root of the result diminished by half the coefficient of the unknown and divided by the coefficient of the square of the unknown is the unknown.[2]

This when expressed in the modern algebraic notations would be

$$x=\frac{\sqrt{ac+(b/2)^2}-(b/2)}{a}$$

Here if the quadratic equation is

$$ax^2+bx+c=0$$

the 'absolute term' is c (the one without the unknown x), 'the coefficient of the square of unknown' means the coefficient of x^2, i.e. a, and the 'coefficient of the unknown' means the coefficient of x, i.e. b.

The above two methods of Brahmagupta are exactly the same as were suggested by Āryabhaṭa I.

The root of the quadratic equation for the number of terms of an arithmetic progression (A.P.) is given by Brahmagupta according to the first rule [2] :

$$n=\frac{\sqrt{8bs+(2a-b)^2}-(2a-b)}{2b}$$

Third Rule :

> Brahmagupta also suggests a Third Rule which is very much the same as is used commonly now. Though it has not been expressedly suggested as a new rule, we find its application in a few instances. For example this rule has been suggested in connection with the following problem on interest :
>
> > A certain sum (p) is lent out for a period (t_1); the interest accrued (x) is lent out again at this

1. वर्गाहत रूपाणामव्यक्तार्धकृति संयुतानां यत् ।
पदमव्यक्तार्धोनं तद्वर्गं विभक्तमव्यक्तः ॥ —*BrSpSi*. XVIII. 45

2. उत्तरहीनद्विगुणादि शेषवर्गं धनोत्तराष्टवधे ।
प्रक्षिप्य पदं शेषोनं द्विगुणोत्तरहृतं गच्छः ॥ —*BrSpSi*. XII. 18

> rate of interest for another period (t_2) and the total amount is A. Find x.

The equation for determining x is

$$\frac{t_2}{pt_1}x^2+x=A.$$

The solution of this equation would be :

$$x=\sqrt{\left(\frac{pt_1}{2t_2}\right)^2+\frac{A\ \ 1}{t_2}}-\frac{pt_1}{2t_2}$$

Brahmagupta has stated the result in exactly the same form. Pṛthūdaka Svāmī has illustrated it in solving the following problem of interest :

Problem :

> A sum of five hundred *paṇas* (p) is lent out for a period of 4 months (t_1); the interest accrued (x) is lent out again at this rate of interest for another period of 10 months (t_2) and the total amount is 78 (A). Give the *pramāṇa-phala*, i.e., the interest accrued x.

Here *pramāṇa-kāla* (t_1)=4 months

pramāṇa-dhana (p)=500 paṇas

para-kāla (t_2), the subsequent period=10 months

miśra dhana or the total interest accrued (A) =78 *paṇas.*

Brahmagupta states his solution of such quadratics like this :

> Take the product of the *pramāṇa-dhana* (p) or the sum originally lent out and *pramāṇa-kāla*, i.e. the period for which originally lent out (t_1); and divide by the *para-kāla* or the subsequent time (t_2); place this result at two places. Multiply the one placed at the first place with the *miśra-dhana* (A), that is with the total interest accrued; in this product add the square of half the one placed in the second place; now take the square-root of it, and from it subtract half of the one placed at the second place.[1]

1. कालप्रमाणघातः परकालहृतो द्विधाऽऽद्यमिश्रवधात् ।
अन्यार्धकृति युतात् पदमन्यार्धोनं प्रमाण फलम् ॥ —*BrSpSi*. *XII*. *15*:

Thus in the above example the product of *pramāṇa-dhana* and *pramāṇa kāla* divided by *parakāla* is (pt_1/t_2) is $\frac{500 \times 4}{10} = 200$. This is first multiplied by the total interest accrued (A); it becomes $200 \times 78 = 15600$. To this is now added square of half of 200 (which is 10000) ; it becomes 15600 plus $10000 = 25600$. Its square-root is taken which is 160. From this is subtracted half of the quantity (i.e. half of 200 which is 100). Thus $160-100=60$, which is the answer. It was the interest which first accrued (x).

Another Quadratic Problem :

Brahmagupta refers to an astronomical problem which involves the quadratic equation

$$(72+a^2)x^2 \mp 24\, apx = 144\left(\frac{R^2}{2} - p^2\right),$$

where a=*agra* (the sine of the amplitude of the Sun), b=*palabhā* (the equinoctial shadow of a gnomon 12 aṅguli long), R=radius, and x=*koṇaśaṅku* (sine of the altitude of the Sun when his altitude is 45°). Dividing out by $(72+a^2)$ we have

$$x^2 \mp 2mx = n,$$

where

$$m = \frac{12\, ap}{72+a^2},\ n = \frac{144(R^2/2-p^2)}{72+a^2}$$

Therefore we have

$$x = \sqrt{m^2+n} \pm m,$$

as stated by Brahmagupta. We find the same result in the *Sūrya-siddhānta* and in the text of Śrīpati. Āryabhaṭa II (1150) also followed the method of Āryabhaṭa I and Brahmagupta in solving a quadratic equation in connection with finding out the number of terms in an arithmetical progression (A.P.) whose first term is (a), common difference is b and the sum is s. The number of terms n is given by[1]

$$n = \frac{\sqrt{2bs+(a-b/2)^2} - a + b/2}{b}$$

Two Roots of a Quadratic Equation and Brahmagupta

A quadratic equation has two roots. This must have been known to Indian algebraists even at a very early stage. Bhāskara II in his *Bījagaṇita* has quoted a rule ascribed to an ancient writer Padmanābha whose works are not available now :

1. *Mahāsiddhānta*, Bhāskara II, XV. 50

> If (after extracting roots) the square-root of the absolute side (of the quadratic) be less than the negative absolute term on the other side, then taking it negative as well as positive two values (of the unknown) are found[1].

The term used here is *dvividhotpadyate mitiḥ* which means that two values are obtained.

The existence of two roots of a quadratic equation appears to have been known also to Brahmagupta (628 A.D.). In illustration of his rules for the solution of a quadratic he has stated two problems involving practically the same equation :

> *Problem I* : The square-root of the residue of the revolution of the Sun less 2 is diminished by 1, multiplied by 10 and added by 2; when will this be equal to the residue of the revolution of the Sun less 1, on Wednesday ?[2]

> *Problem II* : When will the square of one-fourth the residue of the exceeding months less three be equal to the residue of the exceeding months ?

We shall follow Pṛthūdaka Svāmi in solving the Problem I. In this problem the residue of the revolutions of the Sun may be supposed to be x^2+2; then by the question, we have

$$10\,(x-1)+2=x^2+1,$$
$$\text{or } x^2-10x=-9$$

Again in Problem II, if we put $4x$ for the residue of the exceeding month, then we have

$$(x-3)^2=4x$$
$$\text{or } x^2-10x=-9.$$

Now by the second rule of Brahmagupta, retaining both the signs of the radical, we get :

$$x=5\pm\sqrt{25-9}=9 \text{ or } 1,$$

---

1. व्यक्त पक्षस्य चेन्मूलमन्यपक्षर्णरूपतः ।
अल्पं धनर्णगं कृत्वा द्विविधोत्पद्यते मितिः ॥ —Bhaskaka, *Bijagaṇita*

2. मण्डलशेषाद् द्वयूनान्मूलं व्येकं दशाहतं द्वियुतम् ।
मण्डलशेषं व्येकं भानोर्ज्ञदिने कदा भवति ॥ —*BrSpSi.* XVIII. 49

3. अधिमासशेषपादात् त्र्यूनाद्वर्गोऽधिमासशेषसमः ।
अवमावशेषतो वावमशेषसमः कदा भवति ॥ —*BrSpSi.* XVIII. 50.

As shown by Pṛthūdaka Svāmī, the first value is taken by Brahmagupta for the Problem I and second value for the problem II. Thus it is quite clear that Brahmagupta uses sometimes the positive and at other times the negative sign with the radical. Hence we shall say that Brahmagupta knew that a quadratic equation would have two roots, and according to the requisiteness of the problem, one value out of the two would be utilised.

Simultaneous Quadratic Equations

Indian authors usually treated problems involving various forms of simultaneous quadratic equations.

$$\text{(i)}\ \left.\begin{array}{l} x-y=d \\ xy\ \ =b \end{array}\right\} \qquad \text{(ii)}\ \left.\begin{array}{l} x+y=a \\ xy\ \ =b \end{array}\right\}$$

$$\text{(iii)}\ \left.\begin{array}{r} x^2+y^2=c \\ xy=b \end{array}\right\} \quad \text{(iv)}\ \left.\begin{array}{r} x^2+y^2=c \\ x+y=a \end{array}\right\}$$

For the solution of the combination (i), Āryabhaṭa I gives the following rule in his *Āryabhaṭīya* .

> The square-root of four times the product (of two quantities) added with the square of their difference, being added and diminished by their difference and halved gives the two multiplicands.[1]

This means that

$$x=\tfrac{1}{2}\sqrt{d^2+4b}+d),\ \ y=\tfrac{1}{2}(\sqrt{d^2+4b}-d)$$

For the solution of the same combination, Brahmagupta states as follows :

> The square-root of the sum of the square of the difference of the residues and two squared times the product of the residues, being added and subtracted by the difference of the residues, and halved (gives) the desired residues severally.[2]

(Here by difference of the residues is mesnt $x-y$; and by product of the residues is meant xy.)

Brahmagupta does not seem to give the solution for simultaneous equations of the combination (ii). Mahāvīra (850 A.D.)

1. द्विकृति गुणात्संवर्गाद् द्व्यन्तरवर्गेण संयुतान्मूलम् ।
अन्तरयुक्तं हीनं तद्गुणकारद्वयं दलितम् ॥ —*Ārya. II. 24*

2. शेषवधाद् द्वि कृति गुणात् शेषान्तर वर्ग संयुतान्मूलम् ।
शेषान्तरोन युक्तं दलितं शेषे पृथगभीष्टे ॥ —*Br SpSi. XVIII.* 99

has given the solution :

> Subtract four times the area (of a rectangle) from the square of the semi-perimeter then by *saṅkramaṇa* between the square-root of that (remainder) and the semi-perimeter, the base and the upright are obtained.[1] (*GSS.* VII. 129½)

This expressed in the modern notations would be :

$$x=\tfrac{1}{2}(a+\sqrt{a^2-4b}),\ y=\tfrac{1}{2}(a-\sqrt{a^2-4b})$$

For the combination (iii), Mahāvīra in his *Gaṇita-Sāra-Saṃgraha* gives the following rule :

> Add to and subtract twice the area (of a rectangle) from the square of the diagonal and extract the square-roots. By *saṅkramaṇa* between the greater and lesser of these (roots), the side and upright (are found).[2]

This put in modern notations would be :

$$x=\tfrac{1}{2}\ \sqrt{c+2b}+\sqrt{c-2b}).$$
$$y=\tfrac{1}{2}\ (\sqrt{c+2b}-\sqrt{c-2b}).$$

For the combination (iv), Āryabhaṭa I gives the following rule :

> From the square of the sum (of two quantities) subtract the sum of their squares. Half of the remainder is their product.[3]

The remaining operations will be similar to those for the equations (ii); so that

$$x=\tfrac{1}{2}\ (a+\sqrt{2c-a^2}),\ y=\tfrac{1}{2}\ (a-\sqrt{2c-a^2}).$$

Brahmagupta in this connection says :

> Subtract the square of the sum from twice the sum of squares; the square-root of the remainder being added to and subtracted from the sum and halved, (gives) the desired residues.[4]

1. *GSS.* VII. 129½
2. *GSS.* VII. 127½
3. संपर्कस्य हि वर्गाद्विशोधयेदेव वर्गसंपर्कम् ।
   यत्तस्य भवत्यर्धं विद्याद् गुणकारसंवर्गम् ॥ —*Āaya.* II. 23
4. कृति संयोगाद् द्विगुणाद्युति वर्गं प्रोह्य शेष मूलं यत् ।
   तेन युतोनो योगो दलितः शेषे पृथगभीष्टे ॥ —*BrSpSi. XVIII.* 98

These equations have also been treated by Mahāvīra, Bhāskara II and Nārāyaṇa. Nārāyaṇa has attempted two other forms of quadratic equations :

$$\text{(v)}\ \left.\begin{array}{l} x^2+y^2=c \\ x-y=d \end{array}\right\} \qquad \text{(vi)}\ \left.\begin{array}{r} x^2-y^2=m \\ xy=b \end{array}\right\}$$

For their solutions, see Datta and Singh, *Algebra*, P. 84.

Rule of Dissimilar Operations :

Datta and Singh say that the process of solving the following two particular cases of simultaneous quadratic equations was distinguished by most Indian mathematicians by the special designation *viṣama-karma* or dissimilar operation :

$$\text{(i)}\ \left.\begin{array}{l} x^2-y^2=m \\ x-y=n \end{array}\right\} \qquad \text{(ii)}\ \left.\begin{array}{l} x^2-y^2=m \\ x+y=p \end{array}\right\}$$

These equations have been regarded by these mathematicians as if of fundamental importance. They have given the following solutions (expressed in modern algebraic symbols) :

For the combination (i) :

$$x=\tfrac{1}{2}\left(\frac{m}{n}+n\right),\ y=\tfrac{1}{2}\left(\frac{m}{n}-n\right),$$

For the combinaticn (ii) :

$$x=\tfrac{1}{2}\left(p+\frac{m}{p}\right),\ y=\tfrac{1}{2}\left(p-\frac{m}{p}\right).$$

We shall express these solutions as follows in the words of Brahmagupta :

> Thc difference of the squares (of the unknowns) is divided by the difference of the unknowns and the quotient is increased and diminished by the difference and divided by two ; (the results will be the two unknown quantities) ; (this is) dissimilar operation.

The same rule is restated by him on a different occasion in the course of solving a problem.

> If then the difference of their squares, also the difference of them (are given) ; the difference of the squares

1. योगोऽन्तरयुनहीनो द्विहतः संक्रमणमन्तर विभक्तं वा ।
वर्गान्तरमन्तर-युतहीनं द्विहृतं विषमकर्म । *BrSpSi*. XVIII. 36

is divided by the difference of them, and this (latter) is added to and subtracted from the quotient and then divided by two ; (the results are) the residues whence the number of elapsed days (can be found).[1]

This *viṣama-karma* or dissimilar operation has been described by other Indian algebraists also, as Āryabhaṭa II (*Mahāsiddhānta*, XVII, 22); Śrīpati (*Siddhānta-śekhara*, XIV. 13) ; Bhāskara II (*Līlāvatī*) and Nārāyaṇa (*Gaṇita-kaumudī*, I, 32).

Indeterminate Equations of the First Degree

Āryabhaṭa I should be given the credit of giving for the first time a treatment of the indeterminate equation of the first degree. In his *Āryabhaṭīya*, we find a method for obtaining the general solution in positive integers of the simple indeterminate equation :

$$by-ax=c$$

for integral values of a, b, c, and further indicated how to extend it to get positive integral solutions of simultaneous indeterminate equations of the first degree. His disciple Bhāskara I (522) showed that the same method might be applied to solve :

$$by-ax=-c$$

and further that the solution of this equation would follow that of $by-ax=-1$. These methods of Āryabhaṭa I and Bhāskara I have also been adopted by Brahmagupta, and in certain cases, the improvement were suggested by Āryabhaṭa II in the middle of the tenth century A.D.

The problems which were treated by ancient Indian algebraists and which led them to the investigation of the simple indeterminate equation of the first degree may be classified under three heads :

Class I : To find a number N which being divided by two given numbers (a, b) will leave two given remainders (R_1, R_2).

Thus we have :

$$N=ax+R_1=by+R_2$$

---

1. तद्वर्गान्तरमाद्ये तदन्तरं चान्तरोद्धृतयुतोनम् ।
वर्गान्तरं विभक्तं द्वाभ्यां शेषे ततोद्युगणः । *BrSpSi*, XVIII, 97

Hence $by-ax=R_1-R_2$

Putting $c=R_1 \backsim R_2$

we get $by-ax=\pm c$

the upper or lower sign being taken according as R_1 is greater than or less than R_2.

Class II : To find a number (x) such that its product with a given number (α) being increased or decreased by another given number (δ) and then divided by a third given number (β) will leave no remainder.

This means that in other words, we shall have to get the solution of :

$$\frac{\alpha x \pm r}{\beta}=y$$

in positive integers.

Class III : Here we have to deal with an equation of the form :

$$by \div ax= \pm c$$

Kuṭṭaka, Kuṭṭākāra and *Kuṭṭa* : These are the three terms which Brahmagupta has used in regards to the subject of indeterminate analysis of the first degree. Āryabhaṭa I has also described this method in brief, but he does not use the word *kuṭṭaka*. In the *Mahābhāskarīya* of Bhāskara I we have the terms *kuṭṭākāra* and *kuṭṭa* (522 A.D.) *MBh.* I. 41,49). These words have been translated into English as *pulveriser* or *grinder*. Accordin g to Datta and Singh, the Hindu method of solving the equation $by-ax= \pm c$ is essentially based on a process of deriving from it successively other similar equations in which the values of the coefficients (a,b) become smaller and smaller. Thus the process is indeed the same as that of breaking a whole thing into smaller pieces, and this accounts for its name *kuṭṭaka* or '*pulveriser*'.

In the problems of the Class I, the quantities (a and b) are called' divisors' *bhāgahāra, bhājaka, cheda* etc.) and R_1 and R_2 as 'remainders' (*agra* or *śeṣa* etc.). while in a problem of the Class II ; β is ordinarily called the 'divisor' (*bhāgahāra* or *bhājaka*) and γ the 'interpolator' *kṣepa, kṣepaka* etc.) ; here α is called the 'dividend' (*bhājya*), the unkown quantity to be found (x) is called the 'multiplier' or (*guṇaka* or *guṇakāra* etc) and y the

quotient or *phala*. In later years, Mahāvīra has called the unknwn number (x) as *rāśi*.

Preliminary Operations in Kuṭṭaka-Karma

Usually it has been suggested that in order that an equation of the form

$$by - ax = \pm c \text{ or } by + ax = \pm c$$

may be amenable to solution, the two numbers a and b must not have a common divisor; for otherwise, the equation would be absurd, unless the number c had the same common divisor. So before the rules which we shall give hereafter, could be applied, the numbers a, b. c must be made prime (*dṛḍha* or firm; *niccheda* or having no divisor, or *nirapavarta*, meaning irreducible to each other.

In this connection Bhāskara I writes :

> The dividend and divisor will become prime to each other on being divided by the residue of their mutual division. The operation of the pulveriser should be considered in relation to them.[1]

Similarly we find in the writings of Brahmagupta :

> Divide the multiplier and the divisor mutually and find the last residue; those quantities being divided by the residue will be prime to each other.[2]

Āryabhaṭa's Rule : Āryabhaṭa I is probably the first Indian writer on this subject, but the operation given by him is rather obscure. His disciple Bhāskara I has given the solution of indeterminate equations of the first degree in more satisfactory language. We shall give here the translation of Āryabhaṭa's verse from the *Āryabhaṭīya*, as rendered by Bibhutibhusan Datta, because other translations of this verse do very often confuse the sense:

> Divide the divisor corresponding to the greater remainder by the divisor corresponding to the smaller remain-

1. भूदिनेष्टगणान्योन्य भक्तशेषेण भाजितौ ।
हारभाज्यौ दृढौ स्यातां कुट्टाकारं तयोर्विदुः —*MBh*, I. 41

2. हतयोः परस्परं यच्छेषं गुणकारभागहारकयोः ।
तेन हतौ निश्छेदौ तावेव परस्परं हतयोः । —*BrSpSi*. XVIII. 9.

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2. हृतयोः परस्परं यच्छेषं गुणकारभागहारकयोः ।
तेन हृतौ निश्छेदौ तावेव परस्परं हृतयोः । —*BrSpSi*. XVIII. 9.

> der. The residue (and the divisor corresponding to the smaller remainder) being mutually divided, the last residue should be multiplied by such an optional integer that the product being added(in case the number of quotients of the mutual division is even) or subtracted (in case the number of quotients is odd) by the difference of the remainders (will be exactly divisible by the last but one remainder. Place the quotients of the mutual division successively one below the other in a column; below them the optional multiplier and underneath it the quotient just obtained). Any number below .: . the penultimate) is multiplied by the one just above it and then added by that just below it. Divide the last number (obtained by doing so repeatedly) by the divisor corresponding to the smaller remainder; then multiply the residue by the divisor corresponding to the greater remainder and add the greater remainder. (The result will be) the number corresponding to the two divisors.[1]

There is an alternative rendering of this passage also as follows:

> Divide the divisor corresponding to the greater remainder by the divisor corresponding to the smaller remainder. The residue (and the divisor corresponding to the smaller remainder) being mutually divided (until the remainder becomes zero), the last quotient should be multiplied by an optional integer and then added (in case the number of quotients of the mutual division is even) or subtracted (in case the number of quotients is odd) by the difference of the remainders. (Place the other quotients of mutual division successively one below the other in a column; below them the result just obtained and underneath it the optional integer). Any

1. अधिकाग्रभागहारं छिन्द्यादूनाग्रभागहारेण।
शेषपरस्परभक्तं मतिगुणमग्रान्तरे क्षिप्तम् ॥
अध उपरि गुणितमन्त्ययुगूनाग्रच्छेद भाजिते शेषम्।
अधिकाग्रच्छेदगुणं द्विच्छेदाग्रमधिकाग्रयुतम्। —*Ārya*. *II*. 32-33

number below (i.e. the penultimate) is multiplied by the one just above it and then added by that just below it. Divide the last number (obtained by doing so repeatedly) by the divisor corresponding to the smaller remainder; then multiply the residue by the divisor corresponding to the greater remainder and add the greater remainder. (The result will be) the number corresponding to the two divisors.

Āryabhaṭa's problem may be enunciated thus :

To find a number (N) which being divided by two given numbers (a, b) will leave two given remainders (R_1, R_2).

This gives :

$$N=ax+R_1=by+R_2$$

(where R_1 is a greater remainder and R_2 lesser remainder, and a is the divisor corresponding to greater remainder and b the divisor corresponding to the lesser remainder.)

Denoting as before by c the difference between R_1, and R_2, we get

(i) $by=ax+c$, if $R_1>R_2$

(ii) $ax=by+c$, if $R_2>R_1$

the equation being so written as to keep c always positive.

Hence the problem now reduces to making either

$$\frac{ax+c}{b} \text{ or } \frac{by+c}{a}$$

according as $R_1>R_2$ or $R_2>R_1$, a positive integer. So Āryabhaṭa says : Divide the divisor corresponding to the greater remainder etc."

Now we shall proceed with the details of the operation as proposed by Datta and Singh in his *History of Hindu Mathematics, Part II. Algebra* :

Suppose $R_1>R_2$; then the equation to be solved will be

$$ax+c=by \qquad ...(i)$$

a, b being prime to each other.

Let

$$
\begin{array}{l}
b)\ a\ (q \\
\quad \underline{bq} \\
\quad r_1)\ b\ (q_1 \\
\qquad \underline{r_1 q_1} \\
\qquad r_2)\ r_1\ (q_2 \\
\qquad\quad \underline{r_2 q_2} \\
\qquad\quad r_3 \\
\qquad\quad \dots \\
\qquad\quad r_{m-1})\ r_{m-2}\ (q_{m-1} \\
\qquad\qquad \underline{r_{m-1}\ q_{m-1}} \\
\qquad\qquad\quad r_m)\ r_{m-1}\ (q_m \\
\qquad\qquad\qquad \underline{r_m q_m} \\
\qquad\qquad\qquad r_{m+1}
\end{array}
$$

Then we get (when $a < b$, we shall have $q=0$, $r_1=a$)

$$
\begin{aligned}
a &= bq + r_1 \\
b &= r_1 q_1 + r_2 \\
r_1 &= r_2 q_2 + r_3 \\
r_2 &= r_3 q_3 + r_4 \\
\dots & \quad \dots \quad \dots \\
r_{m-2} &= r_{m-1}\ q_{m-1} + r_m \\
r_{m-1} &= r_m q_m + r_{m+1}
\end{aligned}
$$

Now, substituting the value of a in the given equation (1), we get

$$by = (bq + r_1)x + c$$

Therefore

$$y = qx + y_1$$

where

$$by_1 = r_1 x + c$$

In other words, since $a = bq + r_1$, on putting

$$y = qx + y_1 \qquad \text{(ii)}$$

the given equation (i) reduces to

$$by_1 = r_1 x + c \qquad \text{(iii)}$$

Again, since $b = r_1 q_1 + r_2$

putting similarly $x=q_1y_1+x_1$
the equation (iii) can be further reduced to

$$r_1x_1=r_2y_1-c \qquad \text{(iv)}$$

and so on.

Writing down the successive values and reduced equations in columns, we have

(1) $y=qx+y_1$	(I.1) $by_1=r_1x+c$
(2) $x=qy_1+x_1$	(I.2) $r_1x_1=r_2y_1-c$
(3) $y_1=q_2x_1+y_2$	(I.3) $r_2y_2=r_3x_1+c$
(4) $x_1=q_3y_2+x_2$	(I.4) $r_3x_2=r_4y_2-c$
(5) $y_2=q_4x_2+y_3$	(I.5) $r_4y_3=r_5x_2+c$
(6) $x_2=q_5y_3+x_3$	(I.6) $r_5x_3=r_6y_3-c$
....	....
($2n-1$) $y_{n-1}=q_{2n-2}\,x_{n-1}+y_n$	(I. $2n-1$) $r_{2n-2}\,y_n=r_{2n-1}\,x_{n-1}+c$
($2n$) $x_{n-1}=q_{2n-1}\,y_n+x_n$	(I. $2n$) $r_{2n-1}\,x_n=r_{2n}\,y_n-c$
($2n+1$) $y_n=q_{2n}\,x_n+y_{n+1}$	(I. $2n+1$) $r_{2n}\,y_{n+1}=r_{2n+1}\,x_n+c$

Now the mutual division can be continued either (i) to the finish or (ii) so as to get a certain number of quotients and then stopped. In either csse the number of quotients found, neglecting the first one (q). as is usual with Āryabhaṭa, may be even or odd.

Case (i) First suppose that the mutual division is continued until the zero remainder is obtained. Since a, b are prime to each other, the last one remainder is unity.

Subcase (*i*.1.). Let the number of quotients be even. We then have

$$r_{2n}=1,\ r_{2n-1}=0,\ q_{2n}=r_{2n-1}$$

The equations (1,2n) and (I.2n+1), therefore become

$$y_n=q_{2n}\,x_n+c$$

and

$$y_{n+1}=c$$

respectively. Giving an arbitrary integral value (t) to x_n we get an integral value of y_n. From that we can find the value of x_{n-1} by the equation ($2n$). Procceding backwards step by step we ultimately find the values of x and y in positive integers. So that the equation (I) is solved.

Subcase (*i*. 2) : If the number of quotients be odd, we shall have

$$r_{2n-1}=1,\ r_{2n}=0,\ q_{2n-1}=r_{2n-2}.$$

The equations $(2n+1)$ and $(I. 2n+1)$ will then be absent and the equations (I. 2n—1) and (I. 2n) will be reduced respectively to

$$x_{n-1}=q_{2n-1}\, y-c$$

and $x_n=-c$

Giving an arbitrary integral value (t') to y_n we get an integral value of x_{n-1}. Then proceeding backwards as before we calculate the values of x and y.

Case (ii) : Next suppose that the mutual division is stopped after having obtained an even or odd number of quotients.

Subcase (*ii*.1) : If the number of quotients obtained be *even* the reduced form of the original equation is

$$r_2\ y_{+1}=r_{2n+1}\, x_n+c$$

or $$y_{n+1}=\frac{r_{2u+1}\, x_n+c}{r_2}$$

Giving a suitable integral value (t) to x_n as will make

$$y_{n+1}=\frac{r_{2n+1}\, t+c}{r_{2n}}=\text{an integral number,}$$

we get an integral value for y_n by $(2n+1)$. The values of x and y can then be calculated by proceeding as before.

Subcase (*ii*.2) : If the number of quotients be *odd* the reduced form of the quotient is

$$r_{2n-1}\, x_n=r_{2n}\, y_n-c$$

or $$x_n=\frac{r_{2n}\, y_n-c}{r_{2n-1}}$$

Putting $y_n=t'$, where t' is an integer, such that

$$x_n=\frac{r_{2n}\, t'-c}{r_{2n-1}}=\text{a whole number,}$$

we get an integral value of x_{n-1} by $(2n)$. Whence can be calculated the values of x and y in integers.

If $x=\alpha$ and $y=\beta$ be the least integral solution of $ax+c=by$, we shall have

$$a\alpha+c=b\beta$$

Therefore $a(bm+\alpha)+c=b\,(am+\beta)$,
m being any integer. Therefore, in general,

$$x=bm+\alpha$$

But we have calculated before that

$$x = q_1 y_1 + x_1 \,;$$

$$\therefore \quad q_1 y_1 + x_1 = bm + \alpha$$

Thus it is found that the minimum value α of x is equal to the remainder left on dividing its calculated value by b. whence we can calculate the minimum value of $N\,(=a\alpha + R_1)$. This will explain the *rationale* of the operations described in the latter portion of the rule of Āryabhaṭa I.

Bhāskara I and Kuṭṭaka Operation

In Chapter I of the *Mahābhāskarīya*, Bhāskara I has described the preliminary operation to be performed on the divisor and dividend of a pulveriser. We shall quote it from the edition of K.S, Shukla :

> The divisor (which is "the number of civil days in a *yuga*) and the dividend (which is "the revolution number of the desired planet") become prime to each other on being divided by the (last non-zero) residue of the mutual division of the number of civil days in a *yuga* and the revolution number of the desired planet. The operations of the pulveriser should be performed on them (i. e. on the abraded divisor and abraded dividend). So has been said.[1]

An indeterminate equation of the first degree of the type

$$\frac{ax-c}{a}=y$$

(with x and y unknown) is known in Hindu mathematics by the name of "pulveriser"—*kuṭṭākāra*). In this equation, a is called the "dividend" (*bhājya*), b the "divisor" (*bhāgahāra*), c the interpolator (*kṣepa*), x the "multiplier" (*guṇakāra*), and y the "quotient" (*labdha*).

In the pulveriser contemplated in the above stanza :

a=revolution number of a planet.

b=civil days in a *yuga*,

c=residue of the revolutions of the planet (*Śeṣa*)

1. भूदिनेष्टगणान्योन्य भक्तशेषेण भाजि
हारभाज्यौ दृढौ स्यातां कुट्टाकारं तयोर्विदुः । —*MBh.* I. 41

x=*ahargaṇa* ,

and y=complete revolutions performed by the planet.

The text says that as a preliminary operation to the solution of this pulveriser, a and b. i.e., civil days in *yuga* and revolution-number of the planet, should be made prime to each other by dividing them out by their greatest common factor, That is to say, in solving a pulveriser, one should always make use of abraded divisor and abraded dividend.

The interpolator, i.e., the residue, should also be divided out by the same factor. (This instruction is not given in the text, but it is implied that the residue should be computed for the abraded dividend and abraded divisor).

> Set down the dividend above and the divisor (*hāra*) below that. Divide them mutually and write down the quotients (*labdha*) of division one below the other (in the form of a chain). (When an even number of quotients is obtained) think out by what number the (last) remainder be multiplied so that the product being diminished by the (given) residue be exactly divisible (by the divisor corresponding to that remainder). Put down the chosen number called *mati* below the chain and then the new quotient underneath it. Then by the chosen number multiply the number which stands just above it, and to the product add the quotient (written below the chosen number). (Replace the upper number by the resulting sum and cancel the number below). Proceed afterwards also in the same way (until only two numbers remain). Divide the upper number (called the "multiplier") by the divisor by the usual process and the lower one (called the "quotient") by the dividend: the remainders (thus obtained) will respectively be the *ahargaṇa* and the revolutions etc. or what one wants to know.[1]

We shall illustrate the operation by taking a problem from the *Laghu-Bhāskarīya* (VIII. 17) :

> The sum, the difference, and the product increased by one, of the residues of the revolution of Saturn and Mars—each is a perfect square. Taking the equations

furnished by the above and applying the method of such quadratics, obtain the (simplest) solution by the substitution of 2, 3 etc. successively in the general solution). Then calculate the *ahargaṇa* and the revolutions performed by Saturn and Mars in that time together with the number of solar years elapsed.[1]

Let x and y denote the residues of the revolution of Mars and Saturn respectively. Then we have to find out two numbers x and y such that each of the expressions $x+y$, $x-y$ and $xy+1$ may be a perfect square.

Let $x+y=4P^2$ and $x-y=4Q^2$, so that

$$x=2P^2+2Q^2$$
$$y=2P^2-2Q^2$$

and therefore $xy+1=(2P^2-1)^2+4(P^2-Q^4)$

Hence the condition that $xy+1$ be a perfect square is that $P^2=Q^4$. Substituting these values, we have

$$x=2(Q^4+Q^2)$$
$$y=2(Q^4-Q^2)$$

where Q may possess any of the values 2, 3, 4......but not 1. (We neglect the case when x or y is zero).

---

1. भाज्यं न्यसेदुपरि हारमधश्च तस्य ।
खण्डयात्परस्परमधो विनिधाय लब्धम् ।
केनाऽऽहतोऽयमपनीय यथाऽस्य शेषं ।
भागं ददाति परिशुद्धमिति प्रचिन्त्यम् ॥

आप्तां मतिं तां विनिधाय वल्ल्यां
नित्यं ह्यधोऽधः क्रमशश्च लब्धम् ।
मत्या हतं स्यादुपरिस्थितं य
ल्लब्धेन युक्तं पातश्च तद्वत् ॥

हारेणभाज्यो विधिनोपरिस्थो
भाज्येन नित्यं तदधः स्थितश्च ।
अहर्गणोऽस्मिन् भगणादयश्च
तद्वा भवेद्यस्य समीहितं यत् ॥ —*MBh*, I, 42-44

2. शेषौ मण्डलजौ यमक्षितिजयोः संयुक्तविश्लेषिता
वन्योन्याहतविग्रहौ च पददौ रूपेण संयोजितौ ।
एवं साधु विचिन्त्य वर्गविधिना द्वित्रिक्रमाद्वत्स रैः ।
संगण्या द्युगणार्कजक्षिति सुताः कालेन कालोद्भवाः ॥ —*LBh.* VIII. 17

Putting Q=2, we get $x=40$ and $y=24$, which is the least solution.

Assuming now that the residues of the revolution (*maṇḍalaja-śeṣa*) of Saturn and Mars are 24 and 40 respectively, we have to obtain the *ahargaṇa* (which means the number of mean civil days elapsed since the beginning of Kaliyuga, or, in fact, any epoch).

The revolution-number of Saturn is 146564, and the number of civil days in a *yuga* is 1,577,917,500. In the present problem, these are respectively the dividend and the divisor. Their H.C.F. is 4, so that dividing them out by 4 we get 36641 and 394,479,375 as the abraded dividend and abraded divisor respectively. We have, therefore, to solve the pulveriser

$$\frac{36641x-24}{394479375}=y$$

where x and y denote the *ahargaṇa* and the revolutions respectively made by Saturn.

Mutually dividing 36641 and 394479375, we get

```
36641) 394479375 (10766
       394477006
       ---------
            2369) 36641 (15
                  35535
                  -----
                  1106) 2369 (2
                        ----
                         157) 1106 (7
                              1099
                              ----
                                 7) 157 (22
                                    154
                                    ---
                                     3) 7 (2
                                        6
                                        -
                    1×27−24=3)3(1
                                3
                                -
                                0
```

We have chosen here the number 27 as the optional number (*mati*). In fact, *mati* may be chosen at any stage after an even number of quotients are obtained.

Writing down the quotients one below the other as prescribed in the rule, we get the chain

10766
15
2
7
22
2
(*mati*) 27
1

Reducing the chain, we successively get

10766	10766	10766	10766	10766	10766	3108044439 (multiplier)
15	15	15	15	15	288689	288689 (quotient)
2	2	2	2	18665	18665	
7	7	7	8714	8714		
22	22	1237	1237			
2	55	55				
(*mati*) 27	27					
1						

(it would be seen in this reduction of chain that *mati* or 27×2 plus 1 is 55; 55×22 plus 27 is 1237; 1237×7 plus 55 is 8714; 8714×2 plus 1237 is 18665; 18665×15 plus 8714 is 288689; and finally 288689×10766 plus 18665 is 3108044439 which is the multiplier).

Dividing 3108044439 by 394479375, and 288689 by 36641, we obtain 346688814 and 32202 respectively as remainders, (This division is performed only when the multiplier and quotient are greater than the divisor and dividend respectively). These are the minimum values of x and y satisfying the above equation.

Therefore, the required *ahargaṇa*=346688814 and the revolutions performed by Saturn=32202.

To obtain the *ahargaṇa* and the revolutions of Mars, one has to solve the equation :

$$\frac{191402\, z - 40}{131493125} = w$$

where z and w denote the *ahargaṇa* and the revolutions performed by Mars respectively.

The general solution of this equation is

$$z=131493125\,s+118076020$$
$$w=191402\,s+171872$$

where $s=0, 1, 2, 3, \ldots\ldots$ When $s=0$, we have the least solution.

Brahmagupta's Rules Concerning Indeterminate Analysis of the First Degree

For the solution of Āryabhaṭa's problem, Brahmagupta gives the following rule :

> What remains when the divisor corresponding to the greater remainder is divided by the divisor corresponding to the smaller remainder—that (and the latter divisor) are mutually divided and the quotients are severally set down one below the other. The last residue (of the reciprocal division after an even number of quotients has been obtained) is multiplied by such an optional integer that the product being added with the difference of the (given) remainders will be exactly divisible (by the divisor corresponding to that residue). That optional multiplier and then the (new) quotient just obtained should be set down (underneath the listed quotients). Now, proceeding from the lower-most number (in the column), the penultimate is multiplied by the number just above it and then added by the number just below it. The final value thus obtained (by repeating the above process) is divided by the divisor corresponding to the smaller remainder. The residue being multiplied by the divisor corresponding to the greater remainder and added to the greater remainder will be the number in view.[1]

1. अधिकाग्रभागहारादूनाग्रच्छेद भाजिताच्छेषम् ।
यत् तत् परस्परहृतं लब्धमधोऽधः पृथक् स्थाप्यम् ॥
शेषं तदेष्टगुणितं यथाऽग्रयोरन्तरेण संयुक्तम् ।
शुध्यति गुणकः स्थाप्यो लब्धं चान्त्यादुपान्त्यगुणः ॥
स्वोर्ध्वोऽन्त्य युतोऽग्रान्तो हीनाग्रच्छेदभाजितः शेषम् ।
अधिकाग्रच्छेदहत मधिकाग्रयुतं भवत्यग्रम् ॥ —*BrSpSi. XVIII*, 3-5

Brahmagupta further observes :

> Such is the process when the quotients (of mutual division) are even in number. But if they be odd, what has been stated before as negative should be made as positive, or as positive should be made negative.[1]

Regarding the direction for dividing the divisor corresponding to the greater number by the divisor corresponding to the smaller remainder, Pṛthūdaka Svāmī (860A.D.) observes that it is not absolute, rather optional; so that the process may be conducted in the same way by starting with the division of the divisor corresponding to the smaller remainder by the divisor corresponding to the greater remainder. But in this case of inversion of the process, he continues, the difference of the remainders, must be negative.

That is to say, the equation

$$by = ax + c$$

can be solved by transforming it first to the form

$$ax = by - c$$

so that we shall have to start with the division of b by a,

For the details of the "Theory of the pulveriser" as applied to the problems in Astronomy, the reader is referred to the writings of Bhaṭṭa Govind, translated by K.S. Shukla, and given as an Appendix to the edition of the *Laghu-Bhāskarīya*. For the *rationale* of the rules in relation to *kuṭṭaka* or the pulveriser operation, one may also refer to the chapters by Datta and Singh in the *History of Hindu Mathematics: Algebra*.

Solution of $by = ax \pm 1$.

This simple indeterminate equation has a special use in astronomical calculations and therefore, Indian algebraists have paid special attention to it. In fact, this equation is solved exactly in the same way as the equation $by = ax \pm c$; it is a parti-

---

1. एवं समेषु विषमेष्वृणं धनं धनमृणं यदुक्तं तत् ।
ऋणधनयोर्व्यस्तत्वं गुण्य प्रक्षेपयोः कार्यम् ॥ —*BrSpSi*. XVIII. 13.

cular case only of the more general latter equation. Of course, there is a little justification also for treating it separately, since both the types of equations represent two different physical conditions of the astronomical problems. In the case of $by=ax\pm c$, the conditions are such that the value of either y or x, more particularly of the latter, has to be found and the rules for solution formulated with that objective. But in the case of the equation $by=ax\pm 1$, the physical conditions require the values of both y and x.

The equation $by=ax\pm 1$ is usually known by the name *sthira-kuṭṭaka*, literally meaning the '*constant pulveriser*' Pṛthūdaka Svāmī also names it as *dṛḍha-kuṭṭaka* meaning firm-pulveriser. Later on this term *dṛḍha*-was confined to another sense, equivlent to *nicched* (having no divisor) or *nirapavarta* (irreducible), The origin of the name *sthira-kuṭṭaka* or constant pulveriser has been explained by Pṛthūdaka Svāmī as being due to the fact that the interpolator (± 1) is here invariable.

For the solution of this equation, we shall quote Bhāskara I's rule and the rule by Brahmagupta, Bhāskara I writes in this connection as follows :

> The method of the pulveriser is applied also after subtracting unity, The multiplier and quotient are respectively the numbers above and underneath. Multiplying those quantities by the desired number divide by the reduced divisor and dividend; the residues are in this case known to be the (elapsed) days and (residues of) revolutions respectively[1].

The pulveriser

$$\frac{ax-c}{b}=y \qquad \dots (1)$$

may be written as

$$\frac{aX-1}{b}=Y \qquad \dots (2)$$

where $x=cX$ and $y=cY$. If $X=\alpha$, $Y=\beta$ is a solution of (2), then $x=c\alpha$, $y=c\beta$ will be a solution of (i). Hence the above rule.

1. रूपमेकमपास्यापि कुट्टाकारः प्रसाध्यते ।
गुणकारोऽथ लब्धं च राशी स्यातामुपर्यधः ॥ —*MBh. I. 45*

Brahmagupta's Rule in this connection is as follows :
Solution of $by=ax-1$:

> Divide them (i.e., the abraded coefficient of the multiplier and the divisor) mutually and set down the quotients one below the other. The last residue (or the reciprocal division after an even number of quotients has been obtained) is multiplied by an optional integer such that the product being diminished by unity will be exactly divisible (by the divisor correponding to that residue). The (optional) multiplier and then this quotient should be set down (underneath the listed quotients). Now proceeding from the lower most term to the uppermost, by the penultimate multiply the term just above it and then add the lowermost number. (The uppermost number thus calculated being divided by the reduced divisor, the residue (is the quantity required. This is the method of the constant pulveriser[1].

Solution of

$$by+ax=\pm c$$

Indian algebraists usually transformed this equation as $by=-ax+c$, so that it appeared as a particular case of $by=ax+c$, in which a was negative. Brahmagupta has been the first person to solve this equation, but the rule given by him is obscure :

> The reversal of the negative and positive should be made of the multiplier and interpolator.[2]

Pṛthūdaka Svāmī has tried to explain it, but he too is not very clear. He says :

---

1. हतयोः परस्परं यच्छेषं गुणकार भागहारकयोः ।
तेन हृतौ निश्छेदौ तावेव परस्परं हतयोः ॥
लब्धमधोऽधः स्थाप्यं तथेष्ट गुणकारसङ्गुणं शेषम् ।
शुद्ध्यति यथैकहीनं गुणकः स्थाप्यः फलं चान्त्यात् ॥
अग्रान्तमुपान्त्येन स्वोर्ध्वो गुणितोऽन्त्य संयुतो भक्तम् ।
निःशेषभागहारेणैवं स्थिरकुट्टकः शेषम् ॥ —*BrSpSi*. XVIII. 9-11

2. एवं समेषु विषमेष्वृणं धनं धनमृणं यदुक्तं तत् ।
ऋणधनयोर्व्यस्तत्वं गुण्यप्रक्षेपयोः कार्यम् ॥ *BrSpSi* XVIII. 13

> If the multiplier be negative, it must be made positive; and the additive must be made negative : and then the method of the pulveriser should be employed.

Pṛthūdaka Svāmī, however, does not indicate how to derive the solution of the equation .

$$by=-ax+c \qquad ...(1)$$

from that of the equation

$$by=ax-c \qquad ...(2)$$

The method, however, seems to have been this :

> Let $x=\alpha$, $y=\beta$ be the minimum solution of (2). Then we get
>
> $$b\beta=a\,\alpha-c$$
>
> or $$b(a-\beta)=-a(\alpha-b)+c$$

Hence $x=\alpha-b$, $y=a-\beta$ is the minimum solution of (1). This rule is very clearly indicated by Bhāskara II and others.

We shall give two examples from Bhāskara II (*Bījagaṇita*) to illustrate the rule :

Example I.

$$13y=-60x+3$$

By the method described before, we find that the minimum solution of

$$13y=60x+3$$

is $x=11$, $y=51$. Subtracting these values from their respective abraders, namely 13 and 60, we get 2 and 90. Then by the maxim : "In the case of the dividend and divisor being of different signs, the results from the operation of division should be known to be so", making the quotient negative we get the solution of

$$13y=-60x+3$$

as $x=2$, $y=-9$. Subtracting these values again from their respective abraders (13, 60), we get the solution of

$$13y=-60x-3$$

as $x=11$, $y=-51$.

Example II.

$$11y=18x+10$$

Proceeding as before, we find the minimum solution of

$$11y=18x+10$$

to be $x=8$, $y=14$. These will also be the values of x and y in the case of the negative divisor but the quotient for the reasons stated before should be made negative. So the solution of

$$-11y=18x+10$$

is $x=8$, $y=-14$. Subtracting these (i.e., their numerical values) from their respective abraders, we get the solution of

$$-11y=18x-10$$

as $x=3$, $y=-4$,

> "When the divisor is positive or negative the numerical values of the quotient and multiplier remain the same : when either the divisor or the dividend is negative, the quotient must always be known to be negative"[1].

One Linear Equation in More Than Two Unknowns

Whenever a linear equation involves more than two unknown's the Indian algebraists used to assume arbitrary values for all the unknowns except two and then to apply the method of *kuttaka* or "pulveriser". In this connection, Brahmagupta says :

> The method of the pulveriser (should be employed if there be present many unknowns (in any equation)[2],

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1. Bhāskara II gives the following rule :

> "Those(the multiplier and quotient)obtained for a positive dividend being treated in the same manner give the results corresponding to a negative dividend."

> The treatment alluded to in this rule is that of subtraction from the respective abraders. He has further elaborated it thus :

> The multiplier and quotient should be determined by taking the dividend, divisor and interpolator as positive. They will be the quantities for the additive interpolator. Subtracting them from their respective abraders, the quantities for a negative interpolator are found. If the dividend or divisor, be negative, the quotient should be stated as negative, the quotient should be stated as negative.

—*Bījagaṇita*

1. आद्याद्वर्णादन्यान् वर्णान् प्रोह्याद्यमानमाद्यहृतम् ।
सदृशच्छेदावसकृद् द्वौ व्यस्तौ कुट्टको बहुषु ॥ — *BrSpSi. XVIII.* 51

We shall take up one of the problems posed by Brahmagupta concerning astronomy and leading to the equation :[1]

$$197x-1644\,y-z=6302.$$

Hence

$$x=\frac{1644\,y+z+6302}{197}$$

The commentator assumes z=131. Then

$$x=\frac{1644\,y+6433}{197};$$

hence by the usual method of the pulveriser

$$x=41;\ y=1.$$

General Problem of Remainders

A certain type of simultaneous indeterminate equations of the first degree arise out of the general problem of remainders which may thus be stated : To find a number N which being severally divided by $a_1, a_2, a_3 \ldots\ldots a_n$, leaves as remainders $r_1, r_2, r_3, \ldots\ldots r_n$ respectively.

While dealing with such a case, we shall have the following series of equations :

$$N=a_1x_1+r_1=a_2x_2+r_2=a_3x_3+r_3=\ldots\ldots=a_n\,x_n+r\ .$$

We have reasons to believe that the method of solution of these equations was known to Āryabhaṭa I. In the translation of the verse in the *Āryabhaṭīya*, II. 32-33 (the translation of which we have already given), the term *dvicchedāgram* should be translated as "the result will be the remainder corresponding to the product of the two divisors", instead of "the result will be the number corresponding to the two divisors." (the last line of the translation). This explanation is in fact given by Bhāskara I, the direct disciple and earliest commentator of Āryabhaṭa I. Such a rule is clearly stated by Brahmagupta[2].

1. अंशकशेषेण युतात् लिप्ताशेषात्तदन्तरादथवा ।
भानोर्ब्दिने कुगणं यः कथयति कुट्टकज्ञः सः ॥ —*BrSpSi*. XVIII. 55

2. स्वोर्ध्वोऽन्त्ययुतोऽग्रान्तो हीनाग्रच्छेदभाजितः शेषम् ।
अधिकाग्रच्छेदहतमधिकाग्रयुतं भवत्यग्रम् ॥ —*BrSpSi*. XVIII. 5

The rationale of this method is not difficult. I shall quote it from the book of Datta and Singh: Starting with the consideration of the first two divisors, we have

$$N = a_1x_1 + r_1 = a_2x_2 + r_2.$$

By the method described before, we can find the minimum value α of x_1 satisfying this equation. Then the minimum value of N will be $a_1\alpha + r_1$. Hence the general value of N will be given by

$$N = a_1 \ (a_2t + \alpha) + r_1$$
$$= a_1a_2 \ t + a_1\alpha + r_1$$

where t is an integer. Thus $a_1\alpha + r_1$ is the remainder left on dividing N by $a_1 \ a_2$ as stated by Ārybhaṭa I and Brahmagupta, Now taking into consideration the third condition, we have

$$N = a_1a_2t + a_1{}^{\alpha}r_1 = a_3x_3 + r_3$$

which can be solved in the same way as before. Proceeding in this way successively, we shall ultimately arrive at a value of N satisfying all the conditions ;

Pṛthūdaka Svāmī remarks :

> Wherever the reduction of two divisors by a common measure is possible, there 'the product of the divisors' should be understood as equivalent to the product of the divisor corresponding to the greater remainder and quotient of the divisor corresponding to the smaller remainder as reduced (i.e. divided) by the common measure.[1] When one divisor is exactly divisible by the other, then the greater remainder is the (required) remainder and the divisor corresponding to the greater remainder is taken as 'the product of the divisors'. (The truth of) this may be investigated by an intelligent mathematician by taking several symbols.

As an illustration we shall take up a problem quoted by Bhāskara II in his *Bījagaṇita*, and which in its solution follows the method of Āryabhaṭa 1. Pṛthūdaka Svāmī while commenting on serveral verses from Brahmagupta (*BrSpSi.* XVIII. 3–6)

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1. i.e., if p be the L.C.M. of a_1 and a_2, the general value of N satisfying the above two conditions will be

$$N = pt + a_1\alpha + r_1$$

instead of $\quad N = a_1a_2t + a_1\alpha + r_1.$

observes that such problems were very popular amongst the ancient Indian mathematicians.

Problem : To find a number N which leaves remainders 5, 4,3,2 when divided by 6,5,4,3 respectively.

That is to solve the equations :

$$N=6x+5=5y+4=4z+3=3w+2.$$

We have since $N=6x+5=5y+4$,

$$x=\frac{5y-1}{6}$$

But x must be integral, so $y=6t+5$, $x=5t+4$

Hence $N=30t+29$

Again $N=30t+29=4z+3$

$$\text{Therefore, } t=\frac{2z--13}{15}$$

Since t must be integral, we must have $z=15s+14$; hence $t=2s+1$. Therefore

$$N=60s+59.$$

The last condition is identically satisfied. The method given here is the one followed by Pṛthūdaka Svāmī.

Thus when $N=60s+59=6x+5$

$$x=\frac{60s+54}{6}=10s+9 \qquad ...(1)$$

Again, when $N=60s+59=5y+4$,

$$y=\frac{60s+55}{5}=12s+11$$

Again when $N=60s+59=4z+3$

$$z=\frac{60s+56}{4}=15s+14$$

Lastly, when $N=60s+59=3w+2$,

$$w=\frac{60s+57}{3}=20s+19,$$

Varga Prakṛti or Kṛti Prakṛti or Square-Nature

The word *varga-prakṛti* (literally meaning 'square-nature') has been given by Indian algebraists to the indeterminate quadratic equation

$$Nx^2\pm c=y^2$$

Here in this equation the absolute number c should be *rūpa* (or unity). which means the equation

$$Nx^2 \pm 1 = y^2$$

or it may be any absolute number. The most fundamental equation of this class has been regarded as

$$Nx^2 + 1 = y^2$$

where N is a non-square integer.

This branch of mathematics has originated from the number which is the *prakṛti* of the square of *yāvat*, etc. (the unknown x etc.), and therefore, it is called *varga- prakṛti. The quantity* N of *the* a*bove equation is known as Prakṛti*. Brahmagupta uses the term GUṆAKA (*multiplier*) for the same purpose[1].

This term *guṇaka* together with its variation *guṇa* appears occasionally also in the writings of later authors. For example, Śrīpati (*Siddhānta-śekhara*. XIV. 32) employs the term *guṇaka* where as Bhāskara II and Nārāyaṇa use the term *guṇa* in their *Bījagaṇitas*.

In this connection, we would now like to quote from Pṛthūdaka Svāmī (863 A.D.) from his commentary on the *Brāhmasphuṭasiddhānta* :

> Here are stated for ordinary use the terms which are well known to people. The number whose square, multiplied by an optional multiplier and then increased or decreased by another optional number, becomes capable of yielding a square-root, is designated by the term the "lesser root" *kaniṣṭha pada* or the "first root" *ādya-mūla*). The root which results, after those operations have been performed is called by the name the "greater root" (*jyeṣṭha pada*) or the "second root" (*anya-mūla*). If there be a number multiplying both these roots, it is called the "augmenter" (*udvartaka*); and on the contrary, if there be a number dividing the roots, it is called the "abridger" (*apavartaka*).

Thus in the equation

$$Nx^2 \pm c = y^2,$$

1. मूलं द्विधेष्ट वर्गाद् गुणक गुणादिष्टयुत विहीनाच्च ।
आद्यवधो गुणकगुणः सहान्त्यघातेन कृतमन्त्यम् ॥ —*BrSpSi*. XVIII. 64
2. *BrSpSi. XVIII*. 64 (Com.)

x is known as the lesser root, y is the greater root, N is the multiplier (*guṇaka*) and c is interpolator or *kṣepaka*. Bhāskara II has used the word "*hrasvamūla*" for *kaniṣṭha pada* or *ādya-mūla* literally meaning "lsser root". The earlier terms, the "first root" (*ādyamūla*) for the value of x and the "second root" or the "last root" *antya-mūla* for the value of y are quite free from ambiguity Their use is found in the algebra of Brahmagupta. The later terms appears in the works of his commentator Pṛthūdaka Svāmī.

Brahmagupta uses the term *kṣepa*, *prakṣepa* or *prakṣepaka* in the sense of "interpolator." Again, when negative, the interpolator is sometimes distinguished as the "subtractive" or *śodhaka* and the positive interpolator is then called "the additive."

Lemmas of Brahmagupta

Prior to our giving the general solution of the Square-nature or *Varga-Prakṛti*, it would be better to give two Lemmas established by Brahmagupta. We have the following in the *Brāhmasphuṭasiddhānta* :

> Of the square of the optional number multiplied by the *guṇaka* and increased or decreased by an other optional number, *iṣṭa*, (extract) the square root. (Proceed) twice. The product of the first roots multiplied by the *guṇaka* together with the product of the second roots will give a (fresh) second root; the sum of their cross-products will be a (fresh) first root. The (corresponding) interpolator will be equal to the product of the (previous) interpolators.[1]

There is a little difficulty in ascertaing the real sense of the rule given in these lines since the word *dvidhā* (twice) has two implications. Firstly, it may mean that the earlier operations of finding roots are made on two optional numbers with two optional interpolators, and with the results thus obtained the subse-

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1. मूलं द्विधेष्टवर्गाद् गुणक गुणादिष्टयुत विहीनाच्च ।
आद्यवधो गुणकगुणः सहान्त्यघातेन कृतमन्त्यम् ॥
वज्रवधैक्यं प्रथमं प्रक्षेपः क्षेपवध तुल्यः ।
प्रक्षेपशोधकहृते मूले प्रक्षेपके रूपे ॥ —*BrSpSi. XVIII* 64-65

quent operations of their composition are performed. Secondly, it may also mean that the earlier operations are made with one optionally chosen number and one interpolator, and the subsequent ones are carried out after the repeated statement of those roots for the second time. It is also implied that in the composition of the quadratic roots, their products may be added together or subtracted from each other.

In other words, if $x=\alpha$, $y=\beta$ be a solution of the equation :

$$Nx^2+k=y^2,$$

and $x=\alpha'$, $y=\beta'$ be a solution of

$$Nx^2+k'=y^2,$$

then according to the above

$$x=\alpha\beta'\pm\alpha'\beta, \; y=\beta\beta'\pm N\alpha\alpha'$$

is a solution of the equation

$$Nx^2+kk'=y^2.$$

In other words, if

$$N\alpha^2+k=\beta^2$$
$$N\alpha'^2+k'=\beta'^2$$

then

$$N(\alpha\beta'\pm\alpha'\beta)^2+kk'=(\beta\beta'\pm N\alpha\alpha')^2 \qquad \text{(I)}$$

In particular, taking $\alpha=\alpha'$, $\beta=\beta'$ and $k=k'$, Brahmagupta finds from a solution $x=\alpha$, $y=\beta$ of the equation

$$Nx^2+k^2=y^2$$

a solution $x=2\alpha\beta$, $y=\beta^2+N\alpha^2$ of the equation

$$Nx^2+k=y^2$$

That is, if

$$N\alpha^2+k=\beta^2$$

then

$$N(2\alpha\beta)^2+k^2=(\beta^2+N\alpha^2).^2 \qquad \text{(II)}$$

This result will be hereafter called *Brahmagupta's Corollary.*

Thus *Brahmagupta's First Lemma* says that if two solutions of the equation (of the Square-nature) $Nx^2+1=y^2$ are known, then any number of other solutions can be found. For example if two solutions of the Square—nature are (a, b) and also (a',b'), then two other solutions will be :

$$x=ab'\pm a'b, \; y=bb'\pm Naa'.$$

We can compose this solution with the previous ones, and get another solution, and thus proceed on to innumerable solutions. From *Brahmagupta's Corollary to First Lemma* we get another set of solutions. If (a, b) be solution of the Square-nature, then another solution of it is

$$x=2ab, \text{ and } y=b^2+Na^2$$

Thus even if we have only one solution, we can get the other solution also (since N is known), and thus we can get any number of solutions one after the other by this Principle of Composition.

Brahmagupta's Lemmas have been described by Bhāskara II (1150 A.D.) in the following words :

> Set down successively the lesser root (*hrasva*), greater root (*jyeṣṭha*) and interpolator (*kṣepaka*); and below them should be set down in order the same or an another (set of similar quantities). From them by the Principle of Composition (Bhāvanā) can be obtained numerous roots. Therefore the Principle of Composition will be explained here. (Find) the two cross-products (*vajrābhyāsa*) of the two lesser and the two greater roots; their sum is a lesser root. Add the product of the two lesser roots multiplied by the *prakṛti* to the product of the two greater roots, the sum will be a greater root. In that (equation) the interpolator will be the product of the two previous interpolators. Again the difference of the two cross-products is a lesser root. Subtract the product of the two lesser roots multiplied by the *prakṛti* from the product of the two greater roots; (the difference) will be greater root. Here also the interpolator is the product of the two (previous) interpolators.[1]

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1. ह्रस्वज्येष्ठक्षेपकान् न्यस्य तेषां तानन्यान् वाऽधो निवेश्य क्रमेण ।
साध्यान्येभ्यो भावनाभिर्बहूनि मूलान्येषां भावना प्रोच्यतेऽतः ॥
वज्राभ्यासौ ज्येष्ठलघ्वोस्तदैक्यं ह्रस्वं लघ्वोराहतिश्च प्रकृत्या ।
क्षुण्णा ज्येष्ठाभ्यास युग् ज्येष्ठमूलं तत्राभ्यासः क्षेपयोः क्षेपकः स्यात् ॥
ह्रस्वं वज्राभ्यासयोरन्तरं वा लघ्वोर्घातो यः प्रकृत्या विनिघ्नः ।
घातो यश्च ज्येष्ठयोस्तद्वियोगो ज्येष्ठं क्षेपोत्रापि च क्षेपघातः ॥

Bhāskara *II*, *Bījagaṇita*, *VargaPrakṛti*.2-4

Principle of Composition

The above results have been technically known amongst Indian algebraists as *Bhāvanā* (demonstrated or proved, hence theorem or lemma). The word *bhāvanā* also means "composition or combination" in algebra. Bhāvanā may be of two types: *Samāsa Bhāvanā* (or addition Lemma, or additive composition) and *Antara Bhāvanā* (or subtraction Lemma or subtractive composition), Whenever, again, the *bhāvanā* is made with two equal sets of roots and interpolators, it is technically named as *Tulya Bhāvanā* (or composition of equals), and when with two unequal sets of values then it is known as *Atulya Bhāvanā* (or composition of unequals).

Proof of Brahmagupta's Lemmas

It is significant to be indicated that Brahmagupta's Lemmas were rediscovered by Euler in 1764 and by Lagrange in 1768, and a considerable importance was attached to them. Kṛṣṇa, (1580 A.D.) the commentator on the *Bījagaṇita* of Bhāskara II gives the following proof of Brahmagupta's Lemmas:

Let (α,β) and $(\alpha,'\beta')$ be the two solutions of the equation $nx^2+k=y^2$.

we have

$$N\alpha^2+k=\beta^2$$

$$N\alpha'^2+k'=\beta'^2$$

Multiplying the first equation by β'^2, we get

$$N\alpha^2\beta'^2+k\beta'^2=\beta^2\beta'^2$$

Now, substituting the value of factor $\beta^{2\prime}$ of the interpolator from the second equation, we get

$$N\alpha^2\ \beta'^2+k\ (N\alpha'^2+k')=\beta^2\beta'^2$$

or $N(\alpha^2\beta'^2+Nk\alpha'^2+kk'=\beta^2\beta'^2$

Again, substituting the value of k from the first equation in the second term of the left-hand side expression, we have

$$N\alpha^2\beta'^2+N\alpha'^2(\beta^2-N\alpha^2)+kk'=\beta^2\beta'^2$$

or $N(\alpha^2\beta'^2+\alpha'^2\beta^2)+kk'=\beta^2\beta'^2+N^2\alpha^2\alpha'^2$

Adding $\pm 2N\alpha\beta\alpha'\beta'$ to both sides, we get

$$N(\alpha\beta'\pm\alpha'\beta)^2+kk'=(\beta\beta'\pm N\alpha\alpha')^2$$

Brahmagupta's Corollary also follows at once from the above by putting $\alpha'=\alpha$, $\beta'=\beta$ and $k'=k$.

$$N\ (2\alpha\beta)^2+k^2=(\beta^2\pm N\alpha^2)^2$$

Thus the roots are $x=2\alpha\beta$ and $y=\beta^2\pm N\alpha^2$ which is the Corollary.

It would be seen that modern historians of mathematics are incorrect when they say that Fermat (1657) was the first to state that the equation $Nx^2+1=y^2$, where N is a non-square integer has an unlimited number of solutions in integers. For this assertion, history takes us to the early Seventh Century A.D. when Brahmagupta wrote his classical treatise, the *Brāhmasphuṭasiddhānta,* and gave the well known two Lemmas and the Corollary to the first Lemma.

Second Lemma of Brahmagupta

In the *Brāhmasphuṭa siddhānta*, we find another important Lemma by Brahmagupta stated as follows :

> On dividing the two roots (of a square- Nature) by the square-root of its additive or subtracrive, the roots for interpolator unity (will be found).[1]

This Lemma when expressed in the modern language of algebra would mean that if $x=\alpha, y=\beta$ be a solution of the equation.

$$Nx^2+k^2=y^2$$

then $x=\alpha/k$, $y=\beta/k$ is a solution of the equation

$$Nx^2+1=y^2.$$

This rule, at another place, has been re-enunciated as follows:

> If the interpolator is that divided by a square then the roots will be those multiplied by its square-root.[2]

1. प्रक्षेपशोधक हृते मूले प्रक्षेपके रूपे ।

—*BrSpSi.* XVIII. 65

2. वर्गच्छिन्ने क्षेपे तत्पदगुणिते तदा मूले ।

—*BrSpSi.* XVIII. 70

This rule may be expressed in terms of symbols as follows. Suppose the *Varga-prakṛti* (Square-nature) to be

$$Nx^2 \pm p^2 d = y^2,$$

so that its interpolator (*kṣepa*) $p^2 d$ is exactly divisible by the square p^2. Then, putting therein $u = x/p$, $v = y/p$, we derive the equation

$$Nu^2 \pm d = v^2$$

whose interpolator is equal to that of the original Square-nature divided by p^2. It is clear that the roots of the original equation are p times those of the derived equation.

Rational Solution

Indian algebraists have usually suggested the following method to obtain a first solution of $Nx^2 + 1 = y^2$:

> Take an arbitrary small rational number, α, such that its square multiplied by the *guṇaka* N and increased or diminished by a suitably chosen rational number k will be an exact square.

In other words, we shall have to obtain empirically a relation of the form

$$N\alpha^2 \pm k = \beta^2$$

where α, k, and β are rational numbers. Let us call this relation as the *Auxiliary Equation.* Then by Brahmagupta's Corollary, we get from it the relation

$$N(2\alpha\beta)^2 + k^2 = (\beta^2 + N\alpha^2)^2,$$

or $$N\left(\frac{2\alpha\beta}{k}\right)^2 + 1 = \left(\frac{\beta^2 + N\alpha^2}{k}\right)^2$$

Hence, one rational solution of the equation $Nx^2 + 1 = y^2$ is given by

$$x = \frac{2\alpha\beta}{k}, \quad y = \frac{\beta^2 + N\alpha^2}{k}$$

Work on the rational solution of the Square-nature has been also done by Śrīpati. In fact, his solution, given in 1039 A.D. is of historical significance. He derives the rational solution without the aid of the "auxiliary equation." He gives the following rule :

> Unity is the lesser root. Its square multiplied by the *prakṛti* is increased or decreased by the *prakṛti* combined with an (optional) number whose square-root will be the greater root. From them will be obtained two roots by the Principle of Composition[1]

Thus if m^2 be the rational number optionally chosen, one shall have the identity :

$$N.1^2+(m^2-N)=m^2,$$

or

$$N.1^2-(N-m^2)=m^2$$

Then by applying Brahmagupta's Corollary we get

$$N(2m)^2+(m^2 \backsim N)^2=(m^2+N)^2$$

$$\therefore N\left(\frac{2m}{m^2 \backsim N}\right)+1=\left(\frac{m^2+N}{m^2 \backsim N}\right)^2$$

Hence

$$x=\frac{2m}{m \backsim N}\ y=\frac{m^2+N}{m^2 \backsim N}$$

where m is any rational number, is a solution of the equation $Nx^2+1=y^2$.

This rationol solution of the *varga-prakṛti* which was used by Śrīpati in 1039 A.D. was rediscovered in Europe by Brouncker in 1657.

We shall close this discussion by taking an illustration from Bhāskara II :

> *Problem :* Tell me, O mathematician, what is that square which multiplied by 8 becomes, together with unity, a square; and what square multiplied by 11 and increased by unity, becomes a square.

This means that we have to solve the equations :

$$8x^2+1=y^2 \quad ......(i)$$

$$11x^2+1=y^2 \quad ......(ii)$$

In the second example, let us assume 1 as the lesser root. Following the method of Śrīpati, let us multiply its square by the *prakṛti* (here in eq. ii, prakṛti is 11), then let us subtract 2 (an optional number) and then extracting the square-roots we

1. Śrīpati, *Siddhānta-śekhara* XIV. 33

get the greater root as 3. Hence the statement for the composition is

$$m=11 \quad l=1 \quad g=3 \quad i=-2$$
$$l=1 \quad g=3 \quad i=-2$$

Here m=multiplier (*guṇaka* or *prakṛti*). l=lesser root (*kaniṣṭha-mūla*). g=greater root (*jyeṣṭha-mūla*) and i=interpolator (*kṣepa*).

Here we have set down successively the lesser root, greater root and interpolator, and below them again set down the same (See Brahmagupta's Lemmas described by Bhāskara II). Now proceeding as before we obtain the roots for the additive 4 :

$$l=6,\ g=20,\ (\text{for})\ i=4.$$

Then by the rule :

> "If the interpolator (of a *varga-prakṛti* or Square-nature) divided by the square of an optional number be the interpolator (of another Square-nature), then the two roots (of the former) divided by that optional number will be the roots (of the other). Or, if the interpolator be multiplied, their roots should be multiplied."[1]

are found the roots for the additive unity

$$l=3,\ g=10\ (\text{for})\ i=1.$$

Whence by the Principle of Composition of Equals, we get the lesser and greater roots : $l-60$, $g=199$ (for) $i=1$. In this way an infinite number of roots can be deduced.

Alternative method:–Bhāskara II has given another method for finding the two roots for the additive unity :

> Or divide twice an optional number by the difference between the square of that optional number and the *prakṛti*. This (quotient) will be the lesser root (of a Square-nature) when unity is the additive. From that (follows) the greater root.[2]

1. इष्टवर्गहृतः क्षेपः क्षेपः स्यादिष्टभाजिते ।
मूले ते स्तोऽथवा क्षेपः क्षुण्णः क्षुण्णे तदा पदे ॥

Bījagaṇita II. 5.

2. *Siddhānta-śekhara*, XIV. 32.

Let us solve the first example $8x^2+1=y^2$. We assume the optional number to be 3. Its square is 9; the *prakṛti* of multiplier is 8, their difference is 9–8=1. Dividing by this twice the optional number (2×3, i.e. 6), namely 6, we get the lesser root for the additive unity as 6. Whence proceeding as before, we get the greater to be 17, Thus here $x=6$ and $y=17$.

Let us use this method for the equation $11x^2+1=y^2$. Let the optional number be 3. Its square is 9: multiplier or *prakṛti* is 11; the difference is $11-9=2$; dividing by this twice the optional number (2×3), namely 6, we get $6/2=3$, which is the lesser root. Consequently the greater root would be 10, Thus for this equation $x=3$ and $y=10$.

Solution in Positive Integers

The Indian algebraists usually aimed at obtaining solutions of the *varga-prakṛti* or Square-nature in positive integers or *abhinna*. The tentative methods of Brahmagupta and Śrīpati always did not furnish solutions in positive integers. These authors, however, discovered that if the interpolator of auxiliary equation in the tentative method be ±1, ±2 or ±4, an integral solution of the equation $Nx^2+1=y^2$ can always be found. Thus Śrīpati says :

> If 1, 2 or 4 be the additive or subtractive (of the auxiliary equation), the lesser and greater roots will be integral (*abhinna*)[1].

(i) If $k=\pm1$, then the auxiliary equation will be

$$N\alpha^2\pm1=\beta$$

where α and β are intergers. Then by Brahmagupta' Corollary we get

$$x=2\alpha\beta \text{ and } y=\beta^2+N\alpha^2$$

as the required first solution in positive integers of the equation $Nx^2+1=y^2$

1. इष्टवर्गं प्रकृत्योर्यद्विवरं तेन वा भजेत् ।
द्विघ्नमिष्टं कनिष्ठं तद् पदं स्यादेक संयुतौ ।
ततो ज्येष्ठमिहानन्त्यं भावनाभिस्तथेष्टतः ॥

Bījagaṇita, Varga-Prakṛti, 5-6

(ii) Let $k=\pm 2$; then the auxiliary equation is

$$N\alpha^2 \pm 2 = \beta^2$$

By Brahmagupta's Corollary, we have

$$N(2\alpha\beta)^2+4=(\beta^2+N\alpha^2)^2$$

or $$N\ (\alpha\beta)^2+1=\left(\frac{\beta^2+N\alpha^2}{2}\right)^2$$

Hence the required first solution is

$$x=\alpha\beta,\ y=\tfrac{1}{2}(\beta^2+N\alpha^2)$$

Since $$N\alpha^2=\beta^2 \mp 2,$$

we have $\frac{1}{2}\ (\beta^2+N\alpha^2)=\beta^2 \mp 1=$ a whole number.

(iii) Now suppose $k=+4$: so that

$$N\alpha^2+4=\beta^2$$

With an auxiliary equation like this, the first integral solution of the equation $Nx^2+1=y^2$ is

$$x=\tfrac{1}{2}\alpha\beta$$
$$y=\tfrac{1}{2}(\beta^2-2);$$

if α is even; or

$$x=\tfrac{1}{2}\alpha(\beta^2-1)$$
$$y=\tfrac{1}{2}\ \beta\ (\beta^2-2);$$

if β is odd.

Thus we find Brahmagupta saying:

> In the case of 4 as additive the square of the second root diminished by 3, then halved and multiplied by the second root will be the (required) second root: the square of the second root diminished by unity and then divided by 2 and multiplied by the first root will be the (requircd) first root (for the additive unity).[1]

Datta and Singh has given the following *rationale* of this solution.

Since $N\ \alpha^2+4=\beta^2$ (i)

we have $N\ (\alpha/2)^2+1=(\beta/2)^2,$ (ii)

Then by Brahmagupta's Corollary. we get

$$N\ (\alpha\beta/2)^2+1=\left(\frac{\beta^2}{4}+N\frac{\alpha^2}{4}\right)^2$$

---

1. चतुरधिकेऽन्त्यपदकृतिस्त्र्यूनादलिताऽन्त्यपद गुणाऽन्त्यपदम् ॥
अन्त्यपद कृतिर्व्येकाद्विहताऽऽपद्यदाहताऽऽद्यपदम् ॥ —*BrSpSi*. XVIII. 67

Substituting the value of N in the right-hand side expression from (i), we have

$$N\left(\frac{\alpha\beta}{2}\right)^2+1=\left(\frac{\beta^2-2}{2}\right)^2 \qquad \text{(iii)}$$

Composing (ii) and (iii),

$$N\left\{\frac{\alpha}{2}(\beta^2-1)\right\}^2+1=\left\{\frac{\beta}{2}(\beta^2-3)\right\}^2$$

Hence $x=\frac{1}{2}\alpha\beta$, $y=\frac{1}{2}(\beta^2-2)$;
and $x=\frac{1}{2}\alpha(\beta^2-1)$, $y=\frac{1}{2}\beta(\beta^2-3)$;
are solutions of $Nx^2+1=y^2$.

If β be even, the first values of (x,y) are integral. If β be odd, the second values are integral.

(iv) Finally, suppose $k=-4$; the auxiliary equation is

$$N\alpha^2-4=\beta^2$$

Then the required first solution in positive integers of $Nx^2+1=y^2$ is

$$x=\tfrac{1}{2}\alpha\beta(\beta^2+3)(\beta^2+1)$$
$$y=(\beta^2+2)\{\tfrac{1}{2}(\beta^2+3)(\beta^2+1)-1\}.$$

Brahmagupta says:

> In the case of 4 as subtractive, the square of the second is increased by three and by unity; half the product of these sums and that as diminished by unity (are obtained). The latter multiplied by the first sum less unity is the (required) second root; the former multiplied by the product of the (old) roots will be the first root corresponding to the (new) second root.[1]

The rationale of this solution, as given by Datta and Singh is as follows:

$$N\alpha^2-4=\beta^2 \qquad \text{(i)}$$
$$N(\alpha/2)^2-1=(\beta/2)^2$$

Hence by Brahmagupta's Corollary, we get

$$N\left(\frac{\alpha\beta}{2}\right)^2+1=\left(\frac{\beta^2}{4}+N\frac{\alpha^2}{4}\right)^2$$

1. चतुरूनेऽन्त्यपद कृती त्र्येकयुते वधदलं पृथक्त्र्येकम् ।
त्र्येकाद्याहतमन्त्यं पदवध गुणमाद्यमान्त्यपदम् ॥ *BrSpSi. XVIII. 68*

$$=\{\tfrac{1}{2}(\beta^2+2)\}^2 \qquad \text{(ii)}$$

Again applying the Corollary, we get

$$N\ \{\tfrac{1}{2}\alpha\beta(\beta^2+2)\}^2+1=\{\tfrac{1}{2}(\beta^4+4\beta^2+2)\}^2 \qquad \text{(iii)}$$

Now by the Lemma we obtain from (ii) and (iii)

$$N\ \{\tfrac{1}{2}\alpha\beta(\beta^2+3)\ (\beta^2+1)\}^2+1$$
$$=[(\beta^2+2)\{\tfrac{1}{2}(\beta^2+3)\ (\beta^2+1)-1\}]^2$$

Hence $x=\tfrac{1}{2}\alpha\beta(\beta^2+3)\ (\beta^2+1)$,

$$y=(\beta^2+2)\ \{\tfrac{1}{2}(\beta^2+3)\ (\beta^2+1)-1\}$$

is a solution of $Nx^2+1=y^2$

This can be proved without difficulty that these values of x and y are integral. Since If β is even, β^2+2 is also even. And hence the above values of x and y are integral. On the other hand, if β is odd, β^2 is also odd; under these conditions β^2+1 and β^2+3 are even. In this also, therefore, the above values must be integral.

Putting $p=\alpha\beta$, $q=\beta^2+2$, we can write the above solution in the form

$$x=\tfrac{1}{2}p\ (q^2-1).$$
$$y=\tfrac{1}{2}q(q^2-3).$$

This was the form in which the solution was found by Euler.

Cakravāla or Cyclic Method

We have shown in the preceding articles that the most fundamental step in Brahmagupta's method for the general solution in positive integers of the equation

$$Nx^2+1=y^2$$

where N is a non-square integer, is to form an auxiliary equation of the kind

$$Na^2+k=b^2$$

where a and b are positive integers and $k=\pm1$, ±2 or ±4. From this auxiliary equation, by the Principle of Composition, applied repeatedly whenever necessary, one can derive, as we have already shown above, one positive integral solution of the original *Varga-prakṛti* or Square-Nature. And thence again, by means of the same principle, an infinite number of other solutions in integers can be obtained. How to form an auxiliary equation of

this type was a problem, write Datta and Singh, which could not be solved completely nor satisfactorily by Brahmagupta. In fact, Brahmagupta had to depend on trial. Success in this direction was, however, remarkably attained by Bhāskara II. He evolved a simple and elegant method which assisted in deriving an auxiliary equation having the required interpolator $\pm 1, \pm 2$, or ± 4, simultaneously with its two integral roots, from another auxiliary equation empirically formed with any simple integral value of the interpolator, positive or negative. This method has been technically known as *Cakravāla* or the *cyclic method*. This is so called because it proceeds as in a circle, the same set of operations being applied again and again in a continuous round. For the details of this method, our reader is requested to consult the Algebra of Bhāskara II and the narrative on this method as given by Datta and Singh under the title "Cyclic Method" in their *History of Hindu Mathematics*: *Algebra*, 1962 Edition, pp. 161-72.

Solution of Indeterminate Quadratic Equation

It is remarkable to see that Brahmagupta was the first algebraist in the history of mathematics to find a general solution of the indeterminate quadratic equation

$$Nx^2 \pm c = y^2$$

in positive integers. We have the following verse in the *Brāhmasphuṭasiddhānta* in this connection:

> From two roots (of a Square-nature or *varga-prakṛti*) with any given additive or subtractive, by making (combination) with the roots for the additive unity other first and second roots (of the equation having) the given additive or subtractive (can be found).[1]

Let us take the following two equations:

$a_1k = an + b$; and $b_1k = bn + Na$

From them we get: by eliminating n

$$a_1b - ab_1 = 1$$

1. रूप प्रक्षेपपदे पृथगिष्टक्षेप्यशोध्यमूलाभ्याम् ।
कृत्वाऽन्यान्यपदे ये प्रक्षेपे ऽन्ये ॥ —*BrSpSi*. XVIII. 66

Hence $b_1=\frac{a_1b-1}{a}=$ a whole number.

$$\text{Now } n^2-N=\frac{(a_1k-b)^2-Na^2}{a^2}$$
$$=\frac{a_1^2k^2-2bka_1+k}{a^2}$$
$$=\frac{k(a_1^2k-2ba_1+1)}{a^2}$$

Therefore $\frac{k}{a^2}(a_1^2k-2ba_1+1)$ is a whole number.

Since a, k have no common factor, it follows that

$$\frac{a_1^2k-2ba_1+1}{a^2}=\frac{n^2-N}{k}=k_1=\text{an integer.}$$

$$\text{Also } k_1=\frac{n^2-N}{k} = \frac{a_1^2k-2ba_1+1}{a^2}$$
$$=\frac{a_1^2(b^2-Na^2)-2ba_1+1}{a^2}$$
$$=\left(\frac{a_1b-1}{a}\right)^2-Na_1^2.$$

Thus having known a single solution in positive integers of the equation $Nx^2\pm c=y^2$, says, Brahmagupta, an infinite number of other integral solutions can be obtained by making use of the integral solutions of $Nx^2+1=y^2$. If (p,q) be a solution of the former equation found empirically and if (α, β) be an integral solution of the latter, then by the principle of Composition

$$x=p\beta\pm q\alpha;\ y=q\beta\pm Np\alpha$$

will be a solution of the former. Repeating the operations, we can easily deduce as many solutions as we like.

FORM $Mn^2x^2\pm c=y^2$:

In this connection, Brahmagupta says :

If the remainder is that divided by a square, the first root is that divided by its root[1].

This seems to mean that if we have the equation

$$Mn^2x^2\pm c=y^2 \qquad \text{(i)}$$

such that the multiplier (i.e. the coefficient of x^2) is divisible

1. वर्गच्छिन्ने गुणके प्रथमं तन्मूल भाजितं भवति । —*BrSpSi.* XVIII.70

by n^2, then we are justified in saying that if we put $nx=u$, the equation (i) becomes $Mu^2 \pm c = y^2$ (ii),
and clearly the first root of (i) is equal to the first root of (ii) divided by n. The corresponding second root will be the same for both the equations.

FORM $a^2x^2 \pm c = y^2$:

We find Brahmagupta giving the following rule in this connection: This is a solution of a particular form of a *varga-prakṛti* or Square-nature.

> If the multiplier be a square, the interpolator divided by an optional number and then increased and decreased by it, is halved. The former (of these results) is the second root; and the other divided by the square-root of the multiplier is the first root.[1]

Thus the solutions of the equation

$$a^2x^2 \pm c = y^2$$

are :

$$x = \frac{1}{2a}\left(\frac{\pm c}{m} - m\right)$$

$$y = \tfrac{1}{2}\left(\frac{\pm c}{m} + m\right)$$

where m is an arbitrary number.

Bhāskara II and Nārāyaṇa have also given the same solutions as proposed by Brahmagupta.

Rational Geometrical Figures

In the days of the *Taittirīya Saṁhitā* and the *Śatapatha Brāhmaṇa*, Indian mathematicians got familiarity with the solution of such equations

$$x^2 + y^2 = z^2$$

and the results were arrived geometrically on the basis of the law of rectangle as propounded by Baudhāyana in the Śulba Sūtras and which goes by his name. The reader is referred to the Chapter on Baudhāyana, the first Geometer in the author's "*Founders of Sciences in Ancient India*". Baudhāyana (c. 800 B.C.) gave a

1. वर्गे गुणके क्षेपः केनचिदुद्धृतयुतोनितो दलितः ।
प्रथमोऽन्यमूलमन्यो गुणकारपदोद्धृतः प्रथमः ॥ —*BrSpSi*. XVIII. 69

method of transforming a rectangle into a square, which is equivalent to the algebraic identity :

$$mn=\left(m-\frac{m-n}{2}\right)-\left(\frac{m-n}{2}\right).$$

where m, n, are any two arbitrary numbers.

Brahmagupta in connection with the solution of rational triangles says :

> The square of the optional (*iṣṭa*) side is divided and then diminished by an optional number; half the result is the upright, and that increased by the optional number gives the hypotenuse of a rectangle.

We shall put these statements of Brahmagupta in the algebraic language thus : If m, n be any two rational numbers, then the sides of a right-angled triangle will be

$$m,\ \tfrac{1}{2}\left(\frac{m^2}{n}-n\right),\ \tfrac{1}{2}\left(\frac{m^2}{n}+n\right)$$

This Sanskrit term *iṣṭa* may either mean "given" or "optional". With the former meaning the rule would imply the method of finding rational right angles having a given leg.

Brahmagupta was the first to give a solution of the equation $x^2+y^2=z^2$ in integers. His solution is

$$m^2-n^2,\ 2mn,\ m^2+n^2.$$

m and n being two unequal integers.[2]

Thus if $m=7$ and $n=4$, then $m^2-n^2=33$, $2mn=56$ and $m^2+n^2=65$; then the three numbers 33, 56 and 65 bear the relation $33^2+56^2=65^2$.

Mahāvīra (850 A.D.) also states

> The difference of the squares (of two elements) is the upright, twice their product is the base and the sum of their squares is the diagonal of a *generated* rectangle.[2]

Isosceles Triangles with Integral Sides : The following statement of Brahmagupta in this connection is very significant :

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1. इष्टस्य भुजस्य कृतिर्भक्ता नेष्टेन तद्दलं कोटिः ।
आयतचतुरस्रस्य च त्रस्येष्टाधिका कर्णः ॥ —*BrSpSi.* XII. 35

2. *GSS.* VII. 90½

> The sum of the squares of two unequal numbers is the side; their product multiplied by two is the altitude, and twice the difference of the squares of those two unequal numbers is the base of an isosceles triangle.[1]

Thus if m, n be two integers such that m is not equal to n, the sides of all rational isosceles triangles with integral sides are given by

$$m^2+n^2,\ m^2+n^2,\ 2(m^2-n^2)$$

and the altitude of the triangle is $2mn$.

This method was also followed by Mahāvīra and other Indian mathematicians. In fact, their solutions are based on the juxtaposition of two rational right triangles, equal so that they have a common leg. It is remarkably a powerful device, for every rational triangle or quadrilateral may be formed by the juxtaposition of two or four rational right triangles.

Isosceles Triangles with a Given Altitude

Here we have a rule given by Brahmagupta for finding out all rational isosceles triangles possessing the same altitude :

> The (given) altitude is the producer (*karaṇī*). Its square divided by an optional number is increased and diminished by that optional number. The smaller is the base and half the greater is the side.[2]

Thus if m be any rational number then for a given definite altitude a, the sides of the rational isosceles triangles are $\frac{1}{2}\left(\frac{a^2}{m}+m\right)$ each and the base is $\frac{a^2-m^2}{m}$. We shall illustrate it by an example taken from the commentary of Pṛthūdaka Svāmī The given altitude is 8; let us take any rational number $m=4$ then the two equal sides of the isosceles are given by $\frac{1}{2}\left(\frac{8^2+4^2}{4}\right)=$ 10 each and the base is $\frac{8^2-4^2}{4}=12$. Thus the three sides of the

1. कृति युतिर सदृशराश्योर्बाहुर्घातो द्विसंगुणो लम्बः ।
कृत्यन्तरमसदृशयोर्द्विगुणं द्विसमत्रिभुज भूमिः ॥ —*BrSpSi*. XII. 33

2. करणी लम्बस्तत्कृतिरिष्टहृतेष्टेन संयुताऽल्पा भूः ।
अधिको द्विहृतो बाहुः संच्च्यो यद्वधो कर्णः ॥ —*BrSpSi. XII. 37.*

rational isosceles triangle with altitude 8 are (10,10, 12).

Rational Scalene Triangles: Brahmagupta lays down the following rule in the case of rational scalene triangle ;

> The square of an optional number is divided twice by two arbitrary numbers; the moieties of the sums of the quotients and (respective) optional numbers are the sides of a scalene triangle; the sum of the moities of the differences is the base.[1]

In other words, if m, p, q are any rational numbers, then the sides of a rational scalene triangle are :

$$\frac{1}{2}\left(\frac{m^2}{p}+p\right),\ \frac{1}{2}\left(\frac{m^2}{q}+q\right),$$

$$\frac{1}{2}\left(\frac{m^2}{p}-p\right)+\frac{1}{2}\left(\frac{m^2}{q}-q\right)$$

Here the altitude (m), area and segments of the base of this triangle are all rational.

Thus putting $m=12$, $p=6$, and $q=8$ in Brahmagupta's general equation, Pṛthūdaka Svāmī derives a scalene triangle with sides (13,15) and (14) altitude (12), area (84 and the segments of the base (5) which are all integral numbers.

$$\frac{1}{2}\left(\frac{m^2}{p}+p\right)=\frac{1}{2}\left(\frac{12^2}{6}+6\right)=15;$$

$$\frac{1}{2}\left(\frac{m^2}{q}+q\right)=\frac{1}{2}\left(\frac{12^2}{8}+8\right)=13$$

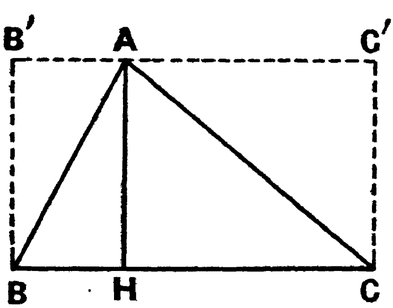


Fig. 19

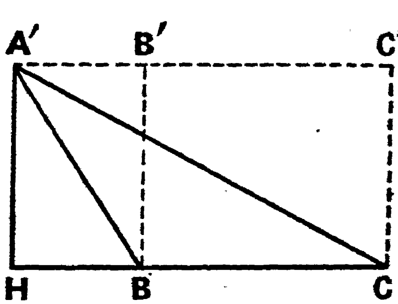


Fig. 20

1. इष्टद्वयेन भक्तो द्विधेष्ट वर्गं फलेष्टयोगार्धे ।
विषमत्रिभुजस्य भुजाविष्टोनफलार्धयोगो भूः ॥

—*BrSpSi*. XII, 34.

Thus the two sides of the rational scalene triangle are 15 and 13. The base is.

$$\frac{1}{2}\left(\frac{12^2}{6}-6\right)+\frac{1}{2}\left(\frac{1^2}{8}-8\right)=9+5=14$$

The altitude is $m=12$; area is equal to $\frac{\text{base}\times\text{altitude}}{2}$

$$=\frac{14\times 12}{2}=\text{and the segments are}\sqrt{13^2-12^2}=5 \text{ and}$$

$\sqrt{(15^2-12^2)}=9$. Thus they are all integers.

Rational Isosceles Trapeziums

Brahmagupta has given us a method of obtaining such isosceles trapeziums whose sides, diagonals, altitude, segments and area are all rational numbers. His rule is as follows:

The diagonals of the rectangle (generated) are the flank sides of an isosceles trapezium; the square of its side is divided by an optional number and then lessened by that optional number and divided by two; (the result) increased by the upright is the base and lessened by it is the face.[1]

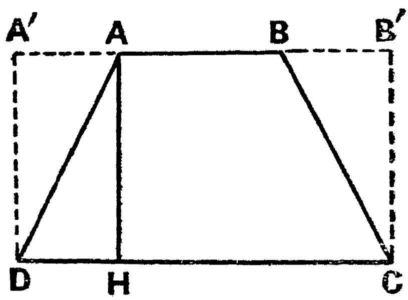


Fig. 21

Here in the figure, we have the isosceles trapezium ABCD of which C D is the base and A B is known as the fase. According to Brahmagupta's rule, we have (p being the optional number).

$$CD=\frac{1}{2}\left(\frac{4m^2n^2-p}{p}\right)+\left(m^2-n^2\right) \qquad \text{(base)}$$

$$AB=\frac{1}{2}\left[\frac{4m^2n^2}{p}-p\right]-\left[m^2-n^2\right] \qquad \text{(face)}$$

$$DH=(m^2-n^2) \qquad \text{(upright)}$$

1. आहतकर्णौ वाहू भुजकृतिरिष्टेन भाजितेष्टोना ।
द्विहृता कोट्यधिका भूमुखमूना द्विसमचतुरस्रे ॥ —*BrSpSi*. XII. 36

$AD = BC = m^2+n^2$ (the sides of the trapezium)

$HC = \text{base}-\text{upright} = \frac{1}{2}\left[\frac{4m^2n^2}{p} - p\right]$ (segment)

$AC = BD = \left[\frac{4m^2n^2}{p} + p\right]$ (diagonal)

$AH = 2\,mn$ (altitude)

$ABCD = mn\left[\frac{4m^2n^2}{p} - p\right]$ (area)

By chosing the values of m n and p suitably, the values of all the dimensions of the isosceles trapezium can be made integral. Pṛthūdaka Svāmī starts with the rectangle (5, 12, 13) and suitably takes p as 6; then he calculates out the dimensions of the trapezium : flank sides (AD and BC) = 13, base =14, and base = 4. altitude (AH) = 12, segments of base (DH and HC) = 5 and 9, diagonals (AC and BD) = 15, area ABCD = 108. All these values are integers.

In this example, the rectangle chosen is (5, 12, 13) which is AA' DH, where $AD = m^2 + n^2 = 13$

and $DH = m^2 - n^2 = 5$

whence by adding the two we have

$2m^2 = 18$

This gives the value of $m = 3$, and hence $n = 2$. Pṛthūdaka Svāmī has taken the value of $p = 6$ by choice. Putting these values of m, n and p, the values for the dimensions of the isosceles trapezium follow from the expressions given by Brahmagupta.

$$CD = \frac{1}{2}\left(\frac{4.3^2.2^2}{6} - 6\right) + \left(3^2-2^2\right) = 9+5 = 14 \text{ (base)}$$

Face = 9−5=4

Sides $AD = BC = 3^2+2^2 = 13$

and so on for the other dimensions.

Rational Trapeziums With Three Equal Sides

This problem is very much the same as one of the rational isosceles tpapezium with the only difference that in this case one of the parallel sides is also equal to the slant sides. We

have the following solution of this problem from Brahmagupta :

> The square of the diagonal (of a *generated* rectangle) gives three equal sides; the fourth (is obtained) by subtracting the square of the upright from thrice the square of the side (of that rectangle). If greater, it is the base; if less, it is the face.[1]

As before, the rectangle generated from m, n is given by (m^2-n^2, $2mn$, m^2+n^2), that is these are the three sides of the right triangle, which correspond to the two sides and the diagonal of the rectangle generated by them. Let us suppose, we have a trapezium ABCD whose sides AB, BC and AD are equal, then

$$AB = BC = AD = (m^2+n^2)^2$$

$$CD = 3(\,2mn\,)^2 - (\,m^2-n^2\,)^2 = 14\,m^2n^2 - m^4 - n^4$$

$$\text{or } CD = 3(\,m^2-n^2\,)^2 - (2mn)^2 = 3m^4+3n^4 - 10\,m^2n^2.$$

Pṛthūdaka Svāmī has taken an illustration, where $m=2$, $n=1$ and he deduces two rational trapeziums with three equal sides (25, 25, 25, 39) and (25, 25, 25, 11).

The segment (CḤ), altitude (AH), diagonals (AC, BD) and area of this trapezium are also rational, and given by :

$$CH\ (\text{ segment }) = 6\,m^2n^2-m^4-n^4$$

$$AH\ (\text{ altitude }) = 4\,mn\,(\,m^2-n^2\,)$$

$$AC = BD\ (\text{ diagonals }) = 4\,mn\,(\,m^2+n^2\,)$$

$$ABCD\ (\text{area }) = 32m^3n^3\,(m^2-n^2\,).$$

Rational Inscribed Quadrilaterals

We find in the *Brāhmasphuṭasiddhānta* a remarkable proposition formulated by Brahmagupta :

> To find all quadrilaterals which will be inscribable within circles and whose sides, diagonals, perpendiculars, segments (of sides and diagonals by perpendiculars from vertices as also of diagonals by their intersection), areas, and also the diameters of the

1. कर्णकृतिस्त्रिसम भुजास्त्रयस्चतुर्थो विशोध्य कोटि कृतिम् ।
बाहुकृतेस्त्रिगुणाया यद्यधिको भूमुखं हीनः ॥ —*BrSpSi.* XII. 37

circumscribed circles will be expressible in integers. Such quadrilaterals we shall call as *Brahmagupta Quadrilaterals.*

The solution of this formidable problem has been given by Brahmagupta as follows :

> The upright and bases of two right-angled triangles being reciprocally multiplied by the diagonals of the other will give the sides of a quadrilateral of unequal sides : (of these) the greatest is the base, the least is the face, and the other two sides are the two flanks.[1]

Taking Brahmagupta's integral solution, the sides of the two right triangles of reference are given by :

(1) m^2-n^2, $2\,mn$, m^2+n^2;

(ii) p^2-q^2, $2\,pq$, p^2+q^2;

where m, n, p, q are integers. Then the sides of the *Brahmagupta Quadrilateral* are.

$$(m^2-n^2)(p^2+q^2),\ (p^2-q^2)(m^2+n^2),$$
$$2mn(p^2+q^2),\ 2pq(m^2+n^2) \qquad \text{(Arrangement } A\text{)}$$

Pṛthūdaka Svāmī has illustrated the rational inscribed quadrilateral by taking an example of the right angle triangles.

(i) (3,4,5) ($m^2-n^2=3$, $m^2+n^2=5$, whence $m=2, n=1$)

(ii) (5,12,13)($p^2-q^2=5$, $p^2+q^2=13$, whence $p=3, q=2$)

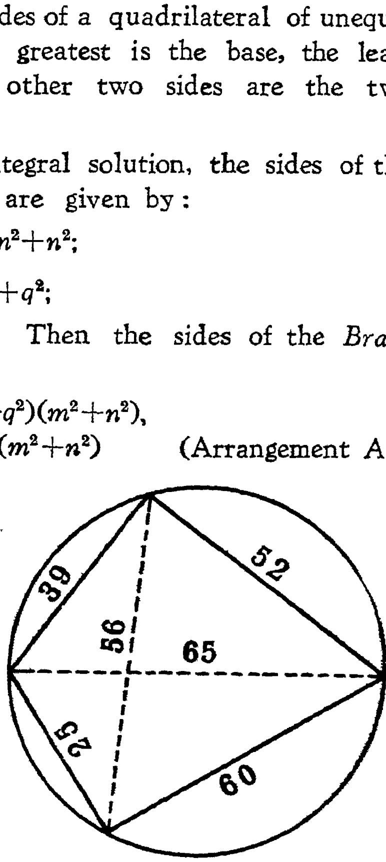


Fig. 22

Substituting these values in the above equations, we get the sides of the quardilateral as (39, 25, 52 and 60).[2]

1. जात्यद्वय कोटिभुजाः परकर्णगुणा भुजाश्चतुर्विषमे ।
अधिको भूमुखहीनो बाहुद्वितयं भुजावन्यौ ॥ —*BrSpSi.* XII. 38

2. The diagonals of this quadrilateral are given by Bhāskara II as 56 (=3.12+4.5) and 63 (=4.12+3.5). *(Cont. on page 268)*

Put in other words, this means that one has to solve the following equations :

(i) $5x-25 = y^2$

(ii) $10x-100 = y^2$

(iii) $83x-7635 = y^2$

Pṛthūdaka Svāmī, the commentator on the *Brāhmasphuṭa-siddhānta* proceeds to solve these equations as follows :

(1.1) Suppose $y = 10$; then $x = 125$. Or put $y = 5$; then $x = 10$.

(2.1) Suppose $y = 10$; then $x = 20$.

(3.1) Assume $y = 1$; then $x = 92$.

He then remarks that by virtue of the multiplicity of suppositions there will be an infinitude of solutions in every case, But no method has been given either by Brahmagupta or his commentator to obtain the general solution.

Double Equations of the First Degree

Perhaps we have the earliest reference of the simultaneous indeterminate quadratic equations of the type

$$x \pm a = u^2$$
$$x \pm b = v^2$$

in the *Bhakaśālī Manuscript* (Folio 59, recto).

Brahmagupta gives the solution of such simultaneous indeterminate quadratic equations of a general case as follows :

> The difference of the two numbers by the addition or subtration of which another number becomes a square, is divided by an optional number and then increased or decreased by it. The square of half the result diminished or increased by the greater or smaller (of the given number) is the number (required).[1]

Expressed in the language of algebra, shall have :

$$= \tfrac{1}{2}\left\{ \frac{1}{2}\left(\frac{a-b}{m} \pm m\right) \right\}^2 \mp a$$

1. याम्यां कृतिरधिको नस्तदन्तरं हृत युतो न मिष्टेन ।
तद्दल कृतिरधिकोनाऽधिकयो रधिको न यो राशिः ॥ —*BrSpSi*. XVIII. 74

$$\text{or } x = \left\{ \tfrac{1}{2} \left(\frac{a-b}{m} \mp m \right) \right\}^2 \mp b$$

where m is an arbitrary number.

Datta and Singh has given the *rationale* of this method as follows :

$$u^2 = x \pm a; \ v^2 = x \pm b,$$

From them, we have $u^2 - v^2 = \pm a \mp b$

Therefore $u - v = m$

$$\text{and } u + v = \frac{\pm a \mp b}{m},$$

where m is arbitrary. Hence

$$u = \tfrac{1}{2} \left(\frac{\pm a \mp b}{m} + m \right) = \pm \tfrac{1}{2} \left(\frac{a-b}{m} \pm m \right)$$

Sincc it is obviously immaterial whether u is taken as positive or negative, we have

$$u = \tfrac{1}{2} \left(\frac{a-b}{m} \pm m \right)$$

$$\text{Similarly } v = \tfrac{1}{2} \left(\frac{a-b}{m} \mp m \right)$$

$$\text{Therefore } x = \left\{ \tfrac{1}{2} \left(\frac{a-b}{m} \pm m \right) \right\}^2 \mp a,$$

$$\text{or } x = \left\{ \tfrac{1}{2} \left(\frac{a-b}{m} \mp m \right) \right\}^2 \mp b,$$

where m is an arbitrary number.

Now we shall take up another particular case, for which Brahmagupta has given a rule :

> The sum of the two numbers tne addition and subtraction of which make another number (severally) a square, is divided by an optional number and then diminished by that optional number. The square of half the remainder increased by the subtractive number is the number (required)[1].

In the algebraic notations, we shall express it as follows :

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1. यैरूनो यैश्च युतो रूपैर्वर्गस्तदैक्यमिष्ट हृतम् ।
इष्टोनं तद्दल कृतिरूनाऽभ्यधिका भवति राशिः ।। —*BrSpSi. XVIII. 71*

$$y=\frac{1}{a}\left(\frac{ad+bc}{m}+b.\right)$$

if $b>c$ and $m>\frac{ad+bc}{m}$. If these conditions be reversed then x and y will have their values interchanged.

Datta and Singh have given the following *rationale* of these solutions :

$$axy=bx+cy+d,$$

or $$a^2xy-abx-acy=ad,$$

or $$(ax-c)\ (ay-b)=ad+bc.$$

Suppose $ax-c=m$, a rational number;

then $ay-b=\frac{ad+bc}{m}$.

Therefore

$$x=\frac{1}{a}(m+c)$$

$$y=\frac{1}{a}\left(\frac{ad+bc}{m}+b\right)$$

Or, we may put $ay-b=m$;

in that case, we shall have $ax-c=\frac{ad+bc}{m}$;

whence $x=\frac{1}{a}\left(\frac{ad+bc}{m}+c\right)$,

$$y=\frac{1}{a}(m+b)\ .$$

Brahmagupta's own rule.

Whilst the rule given above is ascribed to an unknown author, Brahmagupta's own rule for the solution of a quadratic indeterminate equation involving a factum is as follows :

> With the exception of an optional unknown, assume arbitrary values for the rest of the unknowns, the product of which forms the factum. The sum of the product of these (assumed values) and the (respective) coefficients of the unknowns will be absolute quantities. The continued products of the assumed values and of the coefficient of the factum will be the coefficient of the optionally (left out) unknown. Thus the solution

> is effected without forming an equation of the factum Why then was it done so ?[1]

Datta and Singh think that the reference in the latter portion of this rule is to the method of the unknown author :

"*Kiṁ kṛtaṁ tadataḥ*" ? The principle underlying Brahmagupta's method is to reduce, like the Greek Diophantus (c.275 A.D.), the given indeterminate equation to a simple determinate one by assuming arbitrary values for all the unknowns except one. So undoubtedly it is inferior to the earlier method.

We now take an illustrative example from Brahmagupta :

> On subtracting from the product of signs and degrees of the Sun, three and four times (respectively) those quantities, ninety is obtained. Determining the Sun within a year (one can pass as a proficient) mathematician.

If we presume x to denote the signs and y the degrees of the Sun, then the equation would be :

$$xy - 3x - 4y = 90$$

Pṛthūdaka Svāmī solves it in two ways :

(i) Let us assume the arbitrary number to be 17. then

$$x = \frac{1}{1}\left(\frac{90.1+3.4}{17} + 4\right) = 10$$

$$y = \frac{1}{1}\,(17+3) = 20$$

(ii) Let us assume arbitrarily $y=20$. On substituting this value of y in the above equation, we get

$$20x - 3x = 170$$

whence $x = 10$.

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1. भावितके यद्घातो विनष्टवर्णेन तत्प्रमाणानि ।
कृत्वेष्टानि तदाहत वर्णैक्यं भवति रूपाणि ॥
वर्णं प्रमाणभावित घातो भवतीष्ट वर्णं संख्यैवन् ।
सिध्यति विनाऽपि भावित-उपकरणात् किं कृतं तदतः ॥ —*BrSpSi. XVIII. 62-63*

2. भानो राश्यंशवधात् त्रिचतुर्गुणितान् विशोध्य राश्यंशान् ।
नवतिं दृष्ट्वा सूर्यं कुर्वन्नावत्सराद् गणकः ॥ —*BrSpSi. XVIII. 61.*

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Reference

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CHAPTER X

Arabic and Indian Divisions of the Zodiac

I It has long been a debated question whether the Indian and Arabian divisions of the zodiac had a common origin. Sir William Jones thought that they had not; but Colebrooke holds a contrary view. The coincidence, in the two systems of division is so exact that he thinks, it could not be due to chance. Colebrooke has discussed this point in details in one of his Papers entitled "On the Indian and Arabian divisions of the zodiac", *Asiatic Researches* Vol. ix.. p. 323-376, reproduced in the *Miscellaneous Essays*, Vol. II., p. 321-373, 1872.

1. *Aśvinī*, now the first *nakṣatra*, but anciently the last but one, probably obtained its present situation at the head of the asterisms, when the beginning of the zodiacwas referred to the first degree of Meṣa (the Ram). As measuring a portion of the zodiac, it occupies the first 13°20′ of Meṣa; and its beginning follows immediately after the principal star in the last *nakṣatra* Revatī, reckoned by some exactly, by others nearly, opposite to the very conspicuous one, which forms the fourteenth asterism. As a constellation, Aśvinī comprises three stars (Aries α, β, γ) figured as a horse-head; and the principal, which is also the northern one, is stated by all ancient authorities, in 10°N and 8°E. from the beginning of the Meṣa.

According to Arabs, the first manzil or lunar mansion is entitled *Sheratan* (by Persians, *Sheratain*), and comprises two stars of the third magnitude on the head of Aries. in lat. 6°36′ and 7°51′ N and long. 26°13′ and 27°7′. With the addition of a

third, also in the head of the Ram, the asterism is denominated *Āshrait.* The bright star of the second or third magnitude which is out of the figure of the Ram, according to Ulugh Beg, but on the nose according to Hipparchus, cited by this author from Ptolemy, is determined *Nātih* : It is placed in lat. 9°30'N and long. 1 0° 43', and is apparently the same with the principal star of the Indian asterism; for Muhammad of Tizin, in his table of declination and right ascension, expressly terms it the first star of the *Sheratain.*

2. *Bharaṇī*, the second asterism, comprises three stars (35, 39, 41 Aries) figured by the *yoni* or *pudendum muliebre* and the principal and southern star of this nakṣatra is placed in 12°N. On the Arabian system, the second manzil, entitled *Butain* is placed by Ulugh Beg in lat. 1°12′ and 3°12′, and this cannot possibly be reconciled with the Indian constellation. But Muhammad of Tizin assigns to the bright star of *Butain* a declination of 23°N exceeding by nearly 2° the declination allotted by him to *Nātih* or his first star in *Sheratain*. This agrees with the difference between the principal stars of *Aśvinī* and *Bharaṇī*; and it may be inferred, that some among the Mohammadan astronomers have concurred with the Hindus, in referring the second constellation to stars that form Musca.

3. *Kṛttikā*, now the third, formerly the first, *nakṣatra* consists of six stars figured as knife or razor, and the principal and southern star is placed in 4½ or 5°N and in 65 sixths of degrees (or 10°50′) from its own commencement (cf. the *Sūryasiddhānta*). or 37° 28′ to 38° from the beginning of the Meṣa (the *Siddhānta-Śiromaṇi* or the *Graha Lāghava*) respectively. This longitude of the circle of declination corresponds nearly with that of the bright star in the Pleiades, which is 40° of longitude distant from the principal star of *Revatī*.

The stars indicated by Ulugh Beg for *Thurayyā*, also correspond exactly with the Pleiades.

4. *Rohiṇī*, is the fourth *nakṣatra*, the Arabic name for the fourth mansion is *Debarān* (or with the article *Aldebarān*). It corresponds to the bright star called the Bull's eye, and which is unquestionably the same with the principal and eastern star of *Rohiṇī*, placed in 4½° or 5°S and 49¾°E by the Hindu writers on Astronomy. This *nakṣatra* is

figured as a wheel cart, and comprises five stars, out of the seven which the Greeks named the Hyades. The Arabs, however, like the Hindus, reckon five stars only in the asterism. Sir William Jones supposes them to be in the head and neck of the Bull; they probably are α, ρ, γ, δ, ε Tauri, agreeably to Mons. Bally's conjecture.

5. *Mṛgaśirā*, the fifth *nakṣatra*, represented by an antelope head, contains three stars ; the same which constitute the fifth lunar mansion *Hakāh* ; for the distance of 10°S assigned to the northern star of this *nakṣatra*, will agree with no other but one of the three in the head of Orion. The difference of longitude (24° to 25½°) from Kṛttikā corresponds with sufficient exactness; and so does the longitude of its circle of declination (62° to 63°) from the end of Rewatī; since the true longitude of λ Orionis, from the principal star in Revatī (ζ piscium) is 63¼°.

6. *Ārdrā*, the sixth *nakṣatra*, consists of a single bright star, described as a gem, and placed in 9°S (by some in 11°) and at the distance of 4⅔ to 4° in longitude from the last asterism. This indicates the star in the shoulder of Orion (α orionis). The sixth lunar mansion is named by the Arabs as *Hanāh*; and comprises two stars in the feet of the second twin, according to Ulugh Beg, though others make it to be a shoulder. Mohammad of Tizin allots five stars to this constellation; and the Kāmūs, among various meanings of Hanāh, says, that it is a name for five stars in the left arm of Orion; remarking also, that the lunar mansion is named *Tahāyi*, comprising three stars called Tahyāt. Obviously here the Indian and Arabian asterisms are irreconcileable.

7. *Punarvasū* (used in a dual number) is the seventh *nakṣtra*, and is represented by a house, or even a bow, and it includes four stars, among which the principal and eastern one is 30° or 32° from the fifth asterism; but has been placed by all authorities in 6°N. This agrees with (β Geminorum) one of the two stars in the heads of the Twins, which together constitute the seventh lunar mansion *ziraā*, according to Mohammad of Tus and Mohammad of Tizin and other Arabian authorities. The seventh lunar mansion of Arabs is named *ziraā ul ased* according to Jauhari and other cited by Hyde in his Commen-

tary on Ulugh Beg. and that the Kāmūs makes this term to be the name of eight stars in the form of a bow."

8. *Puṣya*, the eighth asterism, is described as an arrow, and consists of three stars, the chief of which being, also the middle most, has no latitude, and is 12° to 13° distant from the seventh asterism, being placed by Hindu astronomers in 106° of longitude. This is evidently δ Cancri; and does not differ widely from the eighth lunar mansion *Nethrah*, which according to Ulugh Beg and others consists of two stars, including the nebula of Cancer. The Indian constellation comprises two other stars besides δ Cancri, which are perhaps γ and β of the same constellation.

9. *Aśleṣā*, the ninth asterism, contains five stars figured as a potter's wheel, and of which the principal or eastern one is placed in 7°S, and according to different tables, 107,° 108° or 109° E. This appears to be intended for the bright star in the southern claw of Cancer (α Cancri), and cannot be reconciled with the lunar mansion *Tarf* or *Tarfah*, which comprises two stars near the lion's (simha) eye, the northernmost being placed by Mohammad of Tizin in 24° of N. declination.

10. *Maghā*, the tenth asterism, contains like the last, five stars, but which are figured as a house. The principal of the Southern one has no latitude; and according to all authorities, has 129° longitude. This is evidently Regulus (α Leonis): which is exactly 129⅔° distant from the last star in *Revatī*. The tenth lunar mansion of Arabians is *Jebhah*, which comprises three (some say, four) stars, nearly in the longitude of the lion's heart. In this instance, therefore, the Indian and Arabian divisions of the zodiac coincide. This *nakastra* consists of α γ ζ η and ν Leonis.

11. *Pūrva-Phālgunī* is the eleventh *nakṣatra* and is represented by a couch or bedstead; it consists of two stars determined by the place of the chief star (the northernmost, according to the *Sūrya-Siddhānta*) in 12°N and 144°E, or according to Brahmagupta, the *Śiromaṇi* and the *Grahalāghava* 147° or 148° E. They are probably δ and θ Leonis. The Arabian name for this lunar mansion is *zubrah* or *Khertān*.

It may be mentioned here that Brahmagupta and Bhāskara selected the southern for the principal star; while the *Sūrya-Siddhānta* took the northern. Hence the latitude stated by several Hindu authorities is the mean between both stars; and the difference of longitude, compared to the preceding and subsequent asterisms, may be exactly reconciled upon this supposition.

12. *Uttara-Phālgunī*, which is the twelfth *nakṣatra*, consists of two stars, and is figured as a bed or cot. These stars are ascertained by the place of one of them (the northernmost) 13°N. and 155° E. This indicates β Leonis; the same which singly constitutes the Arabian Lunar mansion *Serfah*, though Mohammad of Tīzīn seems to hint that it consists of more than one star.

13. *Hasta*, the thirteenth *nakṣatra*, has the name and figure of a hand; and is suitably made to contain five stars. The principal one towards the west, next to the north-western star, is placed according to all authorities in 11° and 170° E. This can only belong to the constellation Corvus ; and accordingly five stars in that constellation (α, β, γ, δ and ε Corvi). The thirteenth lunar mansion of Arabs is *Awwā*, which is also described to contain five stars, situated under Virgo and so disposed as to resemble the letter *Alif*. They are placed by Ulugh Beg in the wing. Here obviously, there is nothing common between the Hindu and Arabian specification of the asterism. The agreement is only in the number of stars and in the longitude.

14. *Citrā*, the fourteenth *nakṣatra*, is figured as pearl. It is placed by the *Sūrya-Siddhānta* in 2° S and 180° E. and by Brahmagupta, the *Śiromaṇi* and *Grahalāghava* in 1¾ or 2°S and 183°E. This agrees with the Virgin's spike (α Virginis). The same star constitutes the fourteenth lunar mansion of the Arabs named from it *Simāc ul aāzi*.

15. *Svāti*, the fifteenth *nakṣatra*, is represented by a coral bead. The *Sūrya-Siddhānta*, Brahmagupta, the *Śiromaṇi* and *Grahalāghava*, all concur in placing it at 37°N. They differ one degree in longitude of its circle of declination, three of them

making it 199° and the other 198°. The Indian asterism totally disagrees with the lunar mansion *Ghafr* which is the fifteenth Arabian mansion. and which consists of three stars in the Virgin's (*Kanyā*) foot, according to Ulugh Beg. but in or near the balance (*Tulā*), according to others.

16. *Viśākhā*, the sixteenth *nakṣatra*, consists of four stars described as a festoon. All the authorities place the principal and northernmost star in 1°, 1°20′ or 1°30′ S and in 212°, 212°5′ or 213° E. The latitude seems to indicate the bright star in the Soutehrn Scale (α Librae), though the longitude disagrees (suggesting possibly a remote star κ Librae). Colebrooke suggests the four stars to be α ν ι Librae and γ Scorpii. The sixteenth lunar mansion according to Arabs is *Zubanah* or *Zubāniyah* according to Mohammad of Tīzīn, the bright star in the northern scale (β Librae).

17. *Anurādhā*, the seventeenth *nakṣatra*, consists of four stars and is described as a row of oblations in a right line. Its chief or middlemost star is placed in 3°, or 2° or 1°45′ S and in 224° or 224°5′E, thus placing it near the head of the Scorpion (*Vṛścika*) (δ Scorpionis) and the asterism comprises β, δ, π, and ρ Scorpionis. The seventeenth lunar mansion of Arabs is called *Iklīl* or *Iklīlu'l-jebhah*, which is said to contain 4, 3, or 6 stars lying in a straight line. Those assigned by Ulugh Beg for this mansion are β, δ, ν and π Scorpionis. Thus here the Indian and Arabian astronomers both concur exactly.

18. *Jyeṣṭha*, the eighteenth *nakṣatra*, comprises three stars figured as a ring. The principal and middlemost star is placed in 4°, 3½° or 3° S and in 229°, 229°5′ or 230°E; this position indicates Antares or the Scorpion's heart (α Scorpionis), which is also the eighteenth lunar mansion, named *Kalb* or *Kalbul'ākrab*. The three stars of Indian asterism may be α, σ and τ Scorpionis.

19. *Mūla*, the nineteenth *nakṣatra*, is represented by a lion's tail, and it contains eleven stars, of which the characteristic one, the easternmost, is placed in 9°, 8½° or 8° S and in 241° or 242° E. This probably (not exactly) indicates ν Scorpionis. This agrees with the eighteenth lunar mansion of Arabs known as *Shaulah*, consisting of two stars near the Scorpion's

sting. The Hindu asterism probably includes all the stars in the Scorpion's tail (ε , μ, ζ, η, θ, ι, κ, λ, υ and ν Scorpionis).

20. *Pūrva-Āṣāḍha*, the twentieth *nakṣatra*, is figured as an elephant's tooth or as a couch, and it consists of two stars, of which the most southern one is placed in 5½°, 5⅓ or 5° S and 254° or 255° E. This corresponds well with δ Sagittarii, and which also corresponds with the twentieth lunar mansion of Arabs called *Nāaim*. The Arabian mansion consists of four, or according to some eight, stars. The Indian *nakṣatra* corresponds to δ and ε Sagittarii.

22. *Uttara-Āṣāḍha*, the twenty-first *nakṣatra*, is represented by a couch or by an elephant's tooth. The principal or the most northerly star is placed in 5° S and 260° or 261° E, agreeing with a star in the body of Sagittarius (τ Sagittarii), and the other star is perhaps the one marked ζ. The Arabian lunar mansion corresponding to it is *Baldah*, consisting of six stars, two, of which are placed by Mohammad of Tīzīn in declination 21° and 16°. One of these must be a star in the head of Sagittarius. Some authors, on the contrary, describe the lunar mansion as destitute of stars. Here the Arabs and Hindus do not show reconciliation.

22. *Abhijit*, the twenty-second asterism, consists of three stars figuring as a triangle or as a nut of floating Trapa (in modern Indian astronomy, it does not occupy an equal portion of the ecliptic with other *nakṣatras*). Its brightest star is very remote from the zodiac, being in 60° or 62° N. The longitude of its circle of declination is 265°, 266° 40′ or 268° according to different authorities. The corresponding lunar mansion of Arabs is *Zābih*, consisting of two stars (according to some, four) in the horns of Capricorn. This totally disagrees with Indian asterism.

20. *Śravaṇa*, the twenty-third *nakṣatra*, is represented by three footsteps, and contains three stars of which the middlemost is placed in 30° N (all authorities agree), and longitude 280° (*Sūrya-Siddhānta*) or 278° (Brahmagupta and *Śiromaṇi*), or 275° (*Grahalāghava*). The assigned latitude indicates the bright star in the Eagle, whence the three may be inferred to be α, β

and γ Aquilae. According to Arabs, the twenty-third lunar mansion is *Balā*, which consists of two stars in the left hand of Aquarius. Here again Arabian and Hindu divisions are at variance.

24. *Dhaniṣṭhā*, the twenty-fourth *nakṣatra*, is represented by a drum or tabor. It comprises four stars, the westernmost of which is placed in 36° N and according to Brahmagupta, *Śiromaṇi* and the *Sūrya-Siddhānta* in 290° E (*Grahalāghava* gives 286°). This longitude of the circle of declination and the distance of the star on it from the ecliptic indicate the Dolphin : and the four stars are α, β, γ and δ Dolphini. The corresponding lunar mansion of Arabs is *Sāud*, which comprises two stars in Aquarius (β and ζ Aquarii). Here again the two divisions disagree completely.

24. *Śatahbiṣak*, the twenty fifth *nakṣatra*, is a cluster of 100 stars figured by a circle. The principal or the brightest has no latitude; or only a third, or at utmost half, a degree of south latitude; and longitude 320°. This best corresponds with λ Aquarii. According to Arabs, the twenty-fifth lunar mansion is known as *Akhbiyah* which consists of three stars only, placed in the wrist of the right hand of Aquarius. However, it appears from Ulugh Beg's tables, as well as from Mohammad of Tīzīn's, that four stars are assigned to this mansion. The Indian and Arabian systems of division differ considerably but less widely according to some.

26. *Pūrva-Bhādrapada*, the twenty-sixth *nakṣatra*, consists of two stars represented by a couch or bed. or else by a double headed figure, one of which is placed in 24° N and 325° or 326° E. The only conspicuous star nearly in that position is the bright star in Pegasus (α Pegasi) and the other may be the nearest considerable star in the same constellation (ζ Pegasi). The twenty-sixth Arabian lunar mansion is *Mukaddim*, consisting of two brightest stars in Pegasus (α and β). Here the Indian and Arabian divisions show concurrence.

27. *Uttar-Bhādrapada*. the twenty-seventh *nakṣatra*, consists of two stars, figured as a twin or a person with double face, or else as a couch. The position of the most northerly of the two

is in 26° or 27°N and 337° E. which probably indicates the bright star in the head of Andromeda, and the other star to be the one in the extremity of the wing of Pegasus (γ Pegasi). This exactly agrees with the twenty-seventh lunar mansion of Arabs named as *Muakkher*. Ulugh Beg assigns those stars to it.

28. *Revatī*, the twenty-eighth *nakṣatra*, comprises thirty-two stars figured as a tabor. The principal star is the southernmost one, it has no latitude, and two of them assert no longitude, but some make it ten minutes short of the origin of the ecliptic, viz. 359° 50'. This clearly marks the star on the ecliptic in the string of the Fishes (ζ Piscium). The ascertainment of this star is important in regard to the adjustment of the Hindu sphere. The Arabic name for this mansion is *Rishā*, signifying a cord. But the constellation as described by Jauhari and cited by Golius, consists of a multitude of stars in the shape of a fish and termed *Betnu'lhūt*; in the navel of which is the lunar mansion. Mohammad of Tīzīn also makes this lunar mansion to be the same with *Betnu'lhūt*, which appears, however, to be the bright star in the girdle of Andromeda (β Andromedae) though others describe it as the northern fish, extending, however, to the horns of Ram. The lunar mansion and the Indian asterism, therefore, are not reconcileable in this last instance.

I leave it to the readers to draw an inference as to the concurrence of the divisions of zodiac in Indian and Arabian systems. I would personally agree with Sir William Jones that the agreements are by chance. Arabs derived the idea of dividing zodiac in 27 or 28 mansions from Indians, or may have got it from Greeks, and then they proceeded in their own way for details. I do not agree with those scholars who sometimes state that the Hindus took the hint of dividing the ecliptic from Greeks. The *Atharvaveda* devotes a number of Sūktas or hymns on Nakṣatras, and I have shown elsewhere that inspired by these hymns, Gārgya was the first Ṛṣi who detailed out the *nakṣatras*. This happened much before Greeks developed even their first notions of astronomy. While the concept of 27 *nakṣatras* is Vedic and most ancient and of purely Indian origin the concept of 12 Rāśis (signs) or twelve constellations is probably inspired from Greeks. [The names Kanyā, (virgo), Tulā

(Libra), Vṛścika (Scorpio), Dhanu, (Sagittarius), Makara, (Capricorn), Kumbha (Aquarius), Mīna (pisces), Meṣa (Aries), Vṛṣa (Taurus), Mithuna (Gemini), Karka (Cancer), and Siṁha (Leo) were not used for Rāśis or signs in the Vedic times]. I shall conclude this description with a passage from Colebrooke :

> The result of comparison shows, I hope satisfactorily, that the Indian asterisms, which mark the divisions of the ecliptic, generally consist of nearly the same stars, which constitute the lunar mansions of the Arabians : but in a few instances, they essentially differ. The Hindus have likewise adopted the division of the ecliptic and zodiac into twelve signs or constellations, agreeing in figure and designation with those of the Greeks; and differing merely in the place of the constellations, which are carried on the Indian sphere a few degrees further west than on the Grecian. That the Hindus took the hint of this mode of dividing the ecliptic from the Greeks, is not perhaps altogether improbable; but if such be the origin of it they have not implicitly received the arrangement suggested to them, but have reconciled and adapted it to their own ancient distribution of the ecliptic into twenty-seven parts.
>
> In like manner, they may have either received or given the hint of an armillary sphere as an instrument for astronomical observation ; but certainly they have not copied the instrument which was described by Ptolemy, for the construction differs considerably.

Names, Shapes, and Number of the Stars of the Nakṣatras

The *Muhūrta-cintāmaṇi* provides a list of shapes associated to the nakṣatras (*MuC.* II. 59-60), In this list we are giving the number of stars as indicated by Varāhamihira, Brahmagupta and Lalla. The identification given here is as indicated by E. Burgess, in his Translation of the *Sūrya-Siddhānta* 1935, p. 378. (Calcutta). This table has been reproduced here from the *Mahābhāskarīya* of Bhāskara I, edited by K.S. Shukla.

Nakṣatra	Shape	Number of stars			Identification
		Varāha	Brahma	Lalla	
Aśvinī	Head of a horse	3	2	3	α, β, γ Aries
Bharaṇī	Yoni	3	3	3	35, 39, 41 Aries
Kṛttikā	Razor	6	6	6	η Tauri etc. (Pleiades)
Rohiṇī	Cart	5	5	5	α, θ, γ, δ, ε Tauri (Hyades)
Mṛgaśirā	Head of a deer	3	3	3	λ, $\phi_1 \phi_2$ Orionis
Ārdrā	Jewel	1	1	1	α Orionis
Punarvasū	House	5	2	4	β, α, ι, υ, μ Geminorum
Puṣya	Arrow-head	3	1	3	θ, δ, γ Cancri
Āśleṣā	Wheel	6	6	5	ε, δ, σ, η, ρ Hydrae
Maghā	House	5	6	5	α, η, ε, ζ, η, ε Leonis
P-Phālgunī	Mañca	8	2	2	δ, θ Leonis
U-Phālgunī	Cot	2	2	2	β, 93 Leonis
Hasta	Hand	5	5	5	δ, γ, ε, α, β corvi
Citrā	Pearl	1	1	1	α Virginis (Spica)
Svātī	Coral bead	1	1	1	α Bootis (Arcturus)
Viśākhā	Arched doorway	5	2	4	ι, γ, β, α, Librae
Anurādhā	Heaps of offerings to gods	4	4	4	δ, β, π Scopionis
Jyeṣṭhā	Earpendent	3	3	3	α, σ, τ Scorpionis
Mūla	Tail of a lion	11	2	11	λ, ν, κ, ι, θ, η, ζ, μ, ε Scorpionis
P-Āṣāḍha	Tusk of elephant	2	4	2	δ, ε Sagittarii
U-Āṣāḍha	Mañca	3	4	2	σ, ξ Sagittarii
Śravaṇa	Three feet	3	3	3	α β, γ Aquilae
Dhaniāṣṭh	Drum	5	5	4	β, α, γ, δ Delphini
Satabhiṣak	Circle	100	1	100	λ Aquarii etc.
P-Bhādra.	Mañca	2	2	2	α, β Pegasi
U-Bhādra	Pair	8	2	2	γ Pegasi; α Andromedae
Revati	Drum	32	1	32	ζ Piscium etc.

Reference

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CHAPTER XI

Brahmagupta's Astronomy : Its Highlights

Beginning or Starting Point

Very often in Indian astronomy, we come across a term *ahargaṇa* (literally meaning collection of days), which means the number of mean civil days elapsed at mean Sunrise at Laṅkā on a given lunar day (*tithi*), since the beginning of *Kaliyuga*. It is the beginning of *Kaliyuga*, which is taken as the starting point for the reckoning of *ahargaṇa*. This happened on Friday, February 18, B.C. 3102, at mean sunrise at Laṅkā, when the Sun, Moon, and the planets are supposed to have been in conjunction at the first point of the *nakṣatra Aśvinī* (which is a fixed point situated near the star ζ-Piscium). According to Āryabhaṭa and Bhāskara I, the duration of Kaliyuga is 1,080,000 solar years. Four times this (4,320,000) is the duration in solar years of a bigger unit called *Mahāyuga* or even *yuga*.

Laṅkā in Indian astronomy is a hypothetical place where the meridian of Ujjain (latitude 23° 11′ N, longitude 75° 52′ E from Greenwich) intersects the equator. It is one of the four hypothetical cities on the equator called Laṅkā, Romaka, Siddhapur and Yamakoṭi (or Yavakoṭi). The *Sūrya-siddhānta* describes Laṅkā as a great city (mahāpurī) situated on an island to the south of Bhāratavarṣa.[1] The present Ceylon is not the

1. समन्तान्मेरुमध्यात्तु तुल्यभागेषु तोयधेः ।
द्वीपेषु दिक्षु पूर्वादिनगर्यो देवनिर्मिताः ॥
भूवृत्त पादे पूर्वस्यां यवकोटीति विश्रुता ।
भद्राश्व वर्षे नगरी स्वर्णप्राकारतोरणा ।
याम्यायां भारतेवर्षे लङ्का तद्वन्महापुरी ॥

(Cont. on page 290)

astronomical Lankā, as it is about six degrees to the north of equator. The astronomical Laṅkā is mentioned by Brahmagupta in the beginning of his very first Chapter[1].

According to Brahmagupta all the four yugas of a *Catur-yuga* or *mahāyuga* are not of the equal duration :

> *Kaliyuga* is of 432,000 years. *Dvāpara* of 864,000 years, *Tretā* of 1,296,000 years and *Kṛtayuga* of 1,728,000 years; total of the four is 4,320,000 years. Āryabhaṭa regards all *yugas* of equal duration, 1,080,000 years[2].

The Saka era, which is usually used in Indian astronomy for the reckoning of years commenced 3179 years after the beginning of *Kaliyuga*.

The number of lunar months in a *yuga* does not coincide with the number of solar months. Thus we have the conception of the *Intercalary months* : the number of intercalary months in a *yuga* denotes the excess of the number of lunar months in a *yuga* over the number of solar months in a *yuga*. Thus in a *yuga* we have

Lunar months	53,433,336
Solar months	51,840,000
Intercalary months	1,593,336
Lunar days	1,603,000,080
Civil days	1.577,917,500
Omitted lunar days	25.082,580

The number of omitted lunar days in a *yuga* is equal to the number of lunar days in a *yuga* minus the number of civil days in a *yuga*.

(*Cont. from page 289*)

पश्चिमेकेतुमालाख्ये रोमकाख्या प्रकीर्तिता ।
उदक्सिद्धपुरी नाम कुरुवर्षे प्रतिष्ठिता ॥ —*Sūrya*. XII. 36-39

1. चैत्रसितादेरुदयाद्भानोर्दिनमासवर्षयुगकल्पाः ।
सृष्ट्यादौ लंकायां समं प्रवृत्ता दिनेऽर्कस्य ॥ —*BrSpSi*. I. 4

2. युगदशभागो गुणितः कृतं चतुर्भिस्त्रिभिर्गुणस्त्रेता ।
द्विगुणो द्वापरमेकेन संगुणः कलियुगं भवति ॥
युगपादानार्यभटश्चत्वारि समानि कृतयुगादीनि ।
यदभिहितवान् न तेषां स्मृत्युक्तसमानमेकमपि ॥ —*BrSpSi*. I. 8-9

Units of time

For the measurements of durations, it is necessary to have units of time. Brahmagupta gives the following units :[1]

6 prāṇas or Asus	=1 Ṛkṣa-vināḍikā or nakṣatra-vighaṭikā or one *pala* (24 seconds)
60 palas	=1 ghatikā (24 minutes)
60 ghaṭikās	=1 divasa or dina (day) (24 hours)
30 dinas	=1 māsa (month)
12 māsas	=1 varṣa or year

Ṣimilar to the divisions of time, we have the divisions of an arc :[2]

Vikalā (or viliptā or viliptikā) =second of arc.

60 vikalās	=1 kalā (minute of arc)
60 kalās	=1 aṁśa (degree of arc)
30 aṁśas	=1 rāśi
12 rāśis	=1 bhagaṇa (complete circle, 360°)

Unlike Āryabhaṭa and others, who take kali, dvāpara, tretā, and kṛta of equal number of years, Brahmagupta regards kali consisting of 432,000 years, dvāpara twice of it, consisting of 864,000 years, tretā thrice of Kali consisting of 1,296,000 years and kṛta four times of kali conisting of thus 1,728,000 years, all the four to be making a *yuga* of 4.320,000 years.[3] Further in the beginning of kṛta there is a *sandhyā* of 1728000/12 years (=144,000 years). and at the end of Kṛta, there is a saṇdhyāṁśa of 144,000 years; similarly in the beginning of tretā, we have a

1. प्राणैर्विनाडिकार्क्षी षड्भिर्घटिका षष्ट्या ।
घटिका षष्ट्या दिवसो दिवसानां त्रिंशता मासाः ॥ —*BrSpSi*. I. 6

2. मासा द्वादशवर्षं विकलालिप्तांशराशिभगणांतः ।
क्षेत्र विभागस्तुल्यः कालेन विनाडिकाद्येन ॥ —*BrSpSi*. I. 6
वर्षं द्वादश मासास्त्रिंशद्दिवसो भवेत्समासस्तु ।
षष्टि नाड्यो दिवसष्षष्टिस्तु विनाडिका नाडी ॥ —*Ārya*. III. 1
गुर्वक्षराणि षष्टिर्विनाडिकार्क्षी षडेव वा प्राणाः ।
एवं काल विभागः क्षेत्र विभागस्तथा भगणात् ॥ —*Ārya*, III. 2

3. खचतुष्टयरदवेदा रवि वर्षाणां चतुर्युगं भवति ।
सन्ध्या सन्ध्यतांशैः सह चत्वारि पृथक् कृतादीनि ॥
युगदशभागो गुणितः कृतं चतुर्भिस्त्रिभिर्गुणस्त्रेता ।
द्विगुणो द्वापरमेकेन संगुणः कलियुगं भवति ॥ —*BrSpSi*. I. 7. 8

sandhyā of 1,296,000/12; i. e. 108,000 years and at the close of tretā a sandhyāṁśa of 108,000 years. Again, in the beginning of dvāpara we have a sandhya of 864,000/12, i. e. 72,000 years and at the close of dvāpara a sandhyāṁśa of 72000 years; and similarly at the beginning a sandhyā and at the close a sandhyāṁśa of 432,000/ 1, i. e. of 36,000 years in the case of kali. In this respect Brahmagupta appears to follow Manu. the first author or giver of law. He regards further the following divisions of time :[1]

71 yugas =1 manu
14 manus =1 kalpa

Again, in the beginning, at the middle and at the close of each manu, there are sandhis, each equal to the measure of kṛta. Thus, taken as a whole

1 kalpa = 71 × 14 yugas + 15 sandhyā-sandhyāṁśa
= 994 yugas + 15 × duration of kṛta
= 994 yugas + 15 × (4 × 432,000) years
= 994 yugas + 6 yugas = 1000 yugas
= 1 Brahma-dina (Brahmā's day)

Thus Brahmā's day is regarded as 1 kalpa or one thousand caturyugis or 1000 *yugas* or the same as 1000 *mahāyugas*).

Āryabhaṭa regards a manu to consist of 72 yugas and therefore a kalpa according to him would be of 14×72 yugas, or 1008 yugas.[2] Since in the foreign Siddhāntas like Romaka, there is no reference to yuga, manu and kalpa, Brahmagupta regards these systems to be unauthoritative.[3]

We have said that our starting point was the beginning of Kaliyuga, Friday February 18, B.C. 3102, at mean rise at Laṅkā, when the Sun, Moon and the planets are supposed to have been in conjunction at the first point of the Nakṣatra Aśvinī. This type of conjunction would again happen after a period of *kalpa*.

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1. मनुरेकसप्ततियुगः कल्पो मनवश्चतुर्दश मनूनाम् ।
आद्यन्तरान्त सन्धिषु कृतकालोऽस्माद्युग सहस्रम् ॥ —*BrSpSi*. I. 10

2. दिव्यं वर्षं सहस्रम् ग्रहसामान्यं युगं द्विषट्क गुणम् ।
अष्टोत्तरसहस्रं ब्राह्मो दिवसो ग्रहयुगानाम् ॥ —*Ārya*. III. 8

3. युगमन्वन्तरकल्पाः कालपरिच्छेदकाः स्मृतावुक्ताः ।
यस्मान्नरोमके ते स्मृतिबाह्यो रोमकस्तस्मात् ॥ —*BrSpSi*. I-13

We shall have the same type of conjunction of *grahocca*, *mandocca* *śīghrocca* and *pāta* after a complete cycle of kalpa as we had in the beginning of creation. This is a natural observable cycle which is recognised in Indian astronomy and in no other foreign system; and hence only the Indian system recognises the time measure of *kalpa*.

Ucca or apex is of two kinds: *mandocca* (apex of the slowest motion) and *śīghrocca* (apex of the fastest motion). The *mandocca* is that point of a planet's orbit which is at the remotest distance and where the motion of the planet is slowest. In the case of the Sun and the Moon, it is the apogee; and in the case of other planets, it is the apogee or aphelion, the geocentric longitude of the apogee being equal to the helio-centric longitude of the aphelion. The *śīghrocca* of a superior planet (Mars, Jupiter and Saturn) is defined as the mean Sun; that of an inferior planet Mercury or Venus) *śīghrocca* is an imaginary body which is supposed to move in such a way that its direction from the earth is always approximately the same as that of the actual planet from the Sun.

The *bhagaṇas* or the revolution numbers of a planet have been given by Āryabhaṭa and Brahmagupta[1] both: they mean the number of revolutions that a planet performs in a certain period, say a kalpa of 4,320,000,000 years.

The *bhagaṇas* of planets are given as follows:

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1. कल्पेऽर्कबुधसितानां भगणाः शून्यानि सप्त रदवेदाः ।
प्राग्व्रजता कुजगुरुशनि शीघ्रोच्चानां स्वकक्षासु ॥
पञ्चाम्बराणि गुण-गुण पञ्चमुनि स्वशरैर्मिताः शशिनः ।
भौमस्य द्वियमशराष्टपक्षवसुरसनवद्वियमाः ॥
कृतवसुनवाष्टनद-नवषट्त्रि नवागेन्दवोज्ञशीघ्रस्य ।
जीवस्य शरेषूदधि षट्पक्षद्वि कृतरसरामाः ॥
सितशीघ्रस्य यमलगोवेदनवाष्टाग्निपक्षयमखनगाः ।
अष्टनवपक्ष मुनि रसशररस मनवोऽर्कपुत्रस्य ॥
खाष्टाब्धयो वसुशरवसुपञ्चखचन्द्रवसुवसुसमुद्राः ।
द्विनवयमा द्वित्रिगुणाः शरेषु वसवस्त्रि पञ्चरसाः ॥
शशिवेदा मन्दानामर्कादीनां विलोमपातानाम् ।
वसुरसरुद्रेन्दुगुणा द्वित्रियमाः सप्तरसपक्षाः ॥
शशियमशरा गुणारसास्त्रिनन्दवसवः समुद्रवसु विषयाः ।
चन्द्रादीनां पश्चात् व्रजतोऽश्विन्यादि भगणस्य ॥ *BrSpSi*. I. 15-21

Planet or a body	Bhagaṇas
Ravi or Sun	4,320,000,000
Budha or Mercury	4,320,000,000
Śukra or Venus	4,320,000,000
Candra or Moon	57,753,300,000
Kuja or Bhauma or Mars	2,296,828,522
Budha-śīghrocca	17,936,998,984
Bṛhaspati or Jupiter	364,226,455
Śukra-śighrocca	7,022,389,492
Śani or Saturn	146,567,298
Arka or Ravi-mandocca	480
Candra mandocca	488,105,858
Kuja or Bhauma mandocca	292
Budha-mandocca	332
Bṛhaspati or Jīva-mandocca	855
Śukra-mandocca	653
Śani-mandocca	41
Candra-pāta	232,311,168
Kuja or Bhauma-pāta	267
Budha-pāta	521
Bṛhaspati or Guru-pāta	63
Śukra-pāta	893
Śani-pāta	584

By pāta is meant the ascending node of a planet's orbit (on the ecliptic).

In a kalpa, the number of *bha-bhramas* (sidereal days) or also known as *bha-parivartas* is 51,040,000,000. If we subtract out from this number the *bhagaṇa* of the Sun, we get what is known as *ku-dinas* or *Sāvana* days or the solar or sacrificial days. (51,040,000,000—4,320,000,000=46,720,000,000 Sāvana days or kudinas).

In a kalpa, the number of Ravi-bhagaṇas also correspond to the number of solar years (Saura-varṣas). i.e., 4,320,000,000; this number multiplied by 12 gives the number (i.e. 51,840,000,000) of solar months.

The difference between the candra-bhagaṇas and the Ravi-bhagaṇas in a kalpa gives the number of lunar months (Cāndra-

māsa) in a kalpa (57,753,300,000-4,320,000,000=53,433,300,000 lunar months).

By subtracting the number of solar months from the number of lunar months in a kalpa, one gets the number of *adhi-māsas* (additional-months) :. 53,433,300,000-51,840,000,000= 1,593,300,000 adhimāsas. This multiplied by 30 gives the number of lunar days (śaśi-divasa) in a kalpa ; 53.433,300,000×30= 1,602,999,000,000 lunar days. The difference between the lunar days and *kudinaṣ* in a kalpa gives the number of *avama-dinas* in a kalpa : 1,602,999,000,000-46,720,000,000=1,556,279,000,000.[1]

Brahmagupta calculates out the sṛṣṭi-saṁvatsara or the Creation Era during his year of composition of the Treatise. He says : Six manus have gone in the kalpa ; the seventh manu is now running of which have lapsed 27 caturyugis ; of the twenty eighth caturyugī, the three yugas, kṛta, dvāpara and tretā have gone by and also of the present kaliyuga 3179 years have lapsed. The total period thus lapsed on calculation comes to be 1,972,947,179 years :[2]

> Total Period=6 manus+7 manu−sandhis+27 yugas +kṛta+dvāpara+tretā+3179 years of kali.
> =(6×71×4,320,000 years) +(7×4×432,000 years)+ (27×4,320,000 years)+(1,728,000+1,296,000+864,000)+ 3,179=1,972,947,179 years.
> =1,840,320,000+12,096,000+116,640,000+3,888,000+ 3,179=1,972,947,179 years.

Calculation of Ahargaṇa : The method of calculating ahargaṇa (number of days elapsed since the beginning of kaliyuga)

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1. परिवर्त्ताः स्वचतुष्टयगराब्धि रसगुणयमद्विवसुतिथयः ।
रवि भगणोना भानोः सावनदिवसाः कुद्विवंसास्ते ॥
रवि भगणारव्यब्दा द्वादशगुणिता भवन्ति रविमासाः ।
भगणान्तरं रवीन्द्वोः शशिमासाः सूर्यमासोनाः ॥
अधिमासाः शशिमासास्त्रिशद्गुणिता भवन्ति शशिदिवसाः ।
शशिसावनदिवसान्तरमवमानि तिथिः शशांकदिनम् ॥ —*BrSpSi*. I. 22-24

2. कल्पपरार्द्धमनवः षट्कस्य गताश्चतुर्युगत्रिघनाः ।
त्रीणिकृतादीनिकलेर्गोऽगैक गुणाः शकान्तेऽब्दाः ॥
नवनगशशि मुनिकृत नव यमनगनन्देन्दवः शकनृपान्ते ।
सार्धमतीतमनूनां सन्धिभिराद्यन्तरान्तगैः ॥ *BrSpSi. I.* 26-27

has been given by Brahmagupta and Bhāskara I is almost identical. The rule given in the *Brāhmasphuṭasiddhānta*[1] may be compared with the following given by Bhāskara I in the *Laghu-Bhāskarīya*:

> Add 3179 to the (number elapsed) years of the Śaka era, (then) multiply (the resulting sum) by 12, and (then) add the (number of lunar) months (expired) since the commencement of Caitra. Set down (the result thus obtained) at (two) separate places; multiply (one) by (the number of) intercalary months in a *yuga*, which are 1,593,336 in a yuga : and divide (the product) by 5,184 × 10,000 (i.e.) by 51,840,000). Add the (resulting complete) intercalary months to the result placed at the other place. Then multiply (that sum) by 30 and (to the product) add the (lunar) days (i.e. *tithis*) expired of the current month. Set down (the result thus obtained) in two places; multiply (one) by the (number of) omitted lunar days in a *yuga* i.e. by 25,082,580 and divide by 1,603,000,080. The resulting (complete) omitted lunar days when subtracted from the result put at the other place give the (required) *ahargaṇa*. The remainder obtained on dividing (the *ahargaṇa*) by 7 gives the day beginning with Friday at sunrise (at Laṅkā)[2]

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1. कल्पगताब्द द्वादशघातश्चैत्रादिमास युक्तोऽधः ।
गुणितो युगाधिमासै रविमासाप्ताधिमास युतः ॥
त्रिंशद्गुणास्तिथियुत्य पृथग् युगावमगुणो युगेन्दु दिनैः ।
भक्तः फलावमोनोऽर्के सावनाहर्गणोऽर्कादिः ॥ — *BrSpSi*. I. 29-30

2. नवाद्र्येकाग्नि संयुक्ताः शकाब्दा द्वादशाहताः ।
चैत्रादिमास संयुक्ताः पृथग् गुण्या युगाधिकैः ॥
ते च षट् त्रिकरामाहित नव भूतेन्दवो युगे ।
भागहारोऽब्धि वस्त्येक शरास्युर युताहताः ॥
अधिमासान्पृथक्स्थेषु प्रक्षिप्य त्रिंशताहते ।
युक्तवादिनानि यातानि प्रतिराश्य युगावमैः ॥
संगुणख्याम्बराष्टेषुद्व्यष्टशून्यशराश्विभिः ।
छेदः खष्टवियद् व्योमख खाग्नि खरसेन्दवः ॥
लब्धान्यवमराठाणि तेषु शुद्धे ष्वहर्गणः ।
वारः सप्तहृते शेषे शुक्रादिर्भास्करोदयात् । —*LBh. I. 4-8*

Addendum : The mean lunar day (*madhyama tithi*) may, however, differ from a true lunar day (*spaṣṭa tithi*) by one, so that the *ahargaṇa* obtained by the above process may sometimes be in excess or defect by *one*. To test whether the *ahargaṇa* (obtained by the above process) is correct, it is divided by seven and the remainder counted with Friday. If this leads to the day of calculation, the *ahargaṇa* is correct; if it leads to the preceding day, the *ahargaṇa* is in defect; and if that leads to the succeeding day, the *ahargaṇa* is in excess. When the *ahargaṇa* is found to be in defect, it is increased by *one*; when it is found to be in excess, it is diminished by *one*. (K.S. Shukla : *MBh.* p. 4–5)

Example—Calculate the *ahargaṇa* on October 1,1965.

From Indian Calendar we find that October 1,1965 falls on Friday. 7th lunar day (tithi) in the light half of the 7th month Āśvina in the Saka year 1887 (elapsed). Let us proceed as follows :

Adding 3,179 to 1,887. we get 5,066. (1)

Multiplying this by 12 and adding 6 (i. e. the number of lunar months elapsed since the beginning of Caitra) we get 60,798. ... ... (2).

Multiplying this by 1,593,336 and dividing the product by 51,840,000, we get 1,868 as quotient. (The remainder is discarded as unnecessary) (3)

Adding this number (i.e. 1,868) to the previous one (i.e.) 60,798) we get 62,666. (4)

Multiplying this by 30 and adding 6 (i.e. the number of lunar days elapsed since the beginning of the current month) to the product, we get 1,879,986. (5)

Multiplying this by 25,082,580 and dividing the product by 1,603,000,080, we get 29,416 as the quotient. (The remainder is discarded as not necessary). (6)

Subtracting this number (i.e. 29,416) from the previous one (i.e. 1,879,986) we get 1,850,570. (7)

This is the required *ahargaṇa*. Since division by 7 leaves

1 as the remainder. we subtract one from it, and get 1,850,569 as the correct *ahargaṇa* for the day.

An Alternative Rule for Ahargaṇa

Both Bhāskara I and Brahmagupta give an alternative rule for calculating out *ahargaṇa*[1] :

> Multiply the number of (solar months) elapsed since the beginning of kaliyuga by the number of lunar months (in a *yuga*) and divide by the number of solar months (in a *yuga*). Reduce the quotient to days (and add the number of lunar days elapsed since the beginning of the current lunar month); then multiply by the number of civil days (in a *yuga*) and divide by the number of lunar days (in a *yuga*); the quotient denotes the *ahargaṇa*.

Mean Longitude of a Planet

(i) The mean longitude of a planet in *revolutions* is given by the expression : (Brahmagupta[2] and also Bhāskara[3]).

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1. शशांकमासैरभिताडितान् हरेदतीतमासानथ वार्कसम्भवैः ।
दिनीकृतान् भूमिदिनैर्हतान् दिनैर्विभज्य लब्धश्शशिजैरहर्गणः ॥ *MBh. I. 7*
युगगतशशिमासवधाद्रविमासाप्तं दिनीकृतं सदिनम् ।
भूदिनगुणितं शशिदिनहृतमाप्तमहर्गणः सैकः ॥ —*BrSpSi.* XIII. 18

2. इष्टग्रह भगण गुणादहर्गणात् कल्पसावन द्यु हृतात् ।
भगणादि फलं मध्यो लंकायां भास्करौदयिकः ॥ *BrSpSi. I. 31*

3. उदारितान् यान् भगणान् क्षमादिनैर्लभामहे कान् कलियातवासरैः ।
इति प्रलब्धा भगणास्ततः क्रमाद् गृहांशलिप्ता विकलाः सतत्पराः ।। —*MBh. I.* 8
पर्ययाहर्गणाभ्यासो ह्रियते भूदिनैस्ततः ।
लभ्यन्ते पर्ययाः शेषाद्राशि भागकलादयः ॥
भास्करैस्त्रिंशता षष्ट्या सङ्गुणय्य पृथक् पृथक् ।
तेनैव भागहारेण लभ्यन्तेऽर्कोदयावधेः ॥ —*LBh. I.* 15-17

(Divide the product of the revolution-number of a planet and the *ahargana* by the (number of) civil days (in a *yuga*); thus are obtained the (number of) revolutions (performed by that planet). From the (successive remainders multiplied respectively by 12,30 and 60 and divided by the same divisor (i.e. the number of civil days in *yuga*) are obtained the signs, degrees and minutes etc. (of the mean longitude of that planet) for (mean) sunrise (at Lanka).

$$\text{Mean longitude} = \frac{\text{revolution number of planet} \times \textit{ahargaṇa}}{\text{civil days in a } \textit{yuga}}$$

Similar expression is given by more recent Indian astronomers also.

(ii) Mean longitude of desired planets in minutes

$$= \frac{\text{(mean longitude of the known planet in revolutions etc. reduced to minutes)} \times \text{(revolution number of the desired planet)}}{\text{revolution number of the known planet.}}$$

This rule is common to Brahmagupta[1] and Bhāskara I[2].

(iii) An alternative rule for deriving the mean longitude of the Moon from that of the Sun and vice versa has been given by Bhāsakara I and Brahmagupta both.

> Multiply the *ahargaṇa* by the number of intercalary months in a yuga and divide (the product) by the number of civil days (in a yuga) : the result is in the terms of revolutions etc. Add that to thirteen times the mean longitude of the Sun. (This is the process) to obtain the mean longitude of the Moon[3].

Mean longitude of the Moon

$$= \frac{\text{(intercalary months in a yuga)} \times \textit{ahargaṇa}}{\text{civil days in a } \textit{yuga}} \text{ revolutions}$$

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1. ज्ञातभगणादिभुक्तं सविकलमिष्टयुग भगणसंगुणितम् ।
ज्ञात युगभगणभक्तं मध्यो भगणादि फलमिष्टः ॥ —*BrSpSi*. XIII. 27

2. निशाकरं वाग्रहमुच्चमेव वा कलीकृतं तत्स्वहयातमण्डलैः ।
यथेष्ट नक्षत्रगणैर्हतं हरेत् तदीयनक्षत्र गणैस्ततः कला ॥ *MBh*. I. 10

The (mean) longitude of the Moon, the planet, or the *Ucca* (whichever is known) together with the revolutions performed should be reduced to minutes. The resulting minutes should then be multiplied by the revolution-number of the desired planet and (the product obtained should be) divided by the revolution-number of that (known) planet. The result is (the mean longitude of the desired planet) in minutes.

3. द्युगणं युगाधिमासैर्गुणितं युग भूदिनैर्भजेल्लब्धम् ।
भगणादि मध्यमार्कं त्रयोदश गुणाधिकं चन्द्रः ॥ —*BrSpSi*. XIII. 33

युगाधिमासैर्द्युगणं हतं हरेत् क्षमादिनैर्वा भगणादि लभ्यते ।
त्रयोदशघ्ने सवितर्यथा क्षिपेन्निशीथिनीनां पतिचारसिद्धये ॥ —*MBh*. I. 11

+13 (Sun's mean longitude)

This expression may be rearranged to get the mean longitude of the Sun from the mean longitude of the Moon[1].

Mean longitude of the Sun

$$= \frac{1}{13}\left[\text{mean longitude of the Moon} - \frac{(\text{intercalary months in a yuga}) \times \textit{ahargaṇa}}{\text{civil days in a yuga}} \text{revolutions}\right]$$

Calculating the Mean Longitudes of the Sun and the Moon without using Ahargaṇa

Bhāskara I follows the method of Āryabhaṭa I and the same method more or less has been adopted by Brahmagupta in calculating the mean longitudes of the Moon and the Sun without the use of *ahargaṇa.* The method may be described thus:

> Reduce the years elapsed since the beginning of kaliyuga to months and add to them elapsed months of the current year. Then multiply the sum by 30 and add the product to the number of lunar days elapsed since the beginning of the current month. Multiply that sum by the number of intercalary months in a *yuga* and divide by the number of solar months in a *yuga* reduced to days; the quotient denotes the number of intercalary months elapsed. The remainder is the *adhimāsaśeṣa*, Multiply the complete intercalary months thus obtained by 30 and to the product add the number of solar days elapsed since the beginning of kaliyuga[2]: then multiply that sum by the number of omitted lunar days in a *yuga* and divide by the number of lunar days in a *yuga* ; the remainder obtained is the *avamaśeṣa* called *āhnika*. Then multiply the *avamaśeṣa*

1. कुसुद्वतीनां सुहृदोऽथवाऽऽगतं विशोध्य शेषस्य लवस्त्रयोदशः ।
स मध्यमार्को गणकैर्निरूप्यते गुरुप्रसादात्प्रति बुद्ध बुद्धिभिः ॥ *MBh.* I. 11-12

2. By the number of solar days here is meant the number obtained above by reducing the years elapsed since the beginning of kaliyuga to months, then adding to them the number of months elapsed since the beginning of the current year, then multiplying the sum by 30, and then adding to the product thus obtained the number of lunar days elapsed of the current month.

(also called *āhnika*) by the number of intercalary months in a *yuga* and divide by the number of civil days (in a *yuga*). Add the resulting quotient to the *adhimāsaśeṣa* and divide the sum by the number of lunar months in a *yuga* : this gives degrees etc. (This is the total *adhimāsaśeṣa*). Next multiply again the *avamaśeṣa* called *āhanika* by 60 and divide by the number of civil days in a *yuga* : the result is in minutes, seconds, thirds etc. The number of months elapsed (since the beginning of Caitra) are to be taken as signs and the number of lunar days elapsed of the current month as degrees. The sum of these signs and degrees and the minutes, seconds etc. corresponding to the avamaśeṣa is the *grahatanu*. From thirteen times and from one time that *grahatanu* severally subtract the degrees, minutes etc. corresponding to the total *adhimāsaśeṣa* : the remainders thus obtained are the mean longitudes of the Moon and the Sun respectively[1].

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1. गुणिताद्युगाधिमासैर्युगभूदिवसैर्हृतादवमशेषात् ।
फलयुक्तमधिकमासकशेषं मध्यावतोऽर्केन्दू ॥
अधिमासावमशेषे युगशशि भूदिनहृते पृथग्लब्धेः ।
मासदिनाद्ये स्थाप्ये गतमासदिनानि चैत्रादेः ॥
अवमासशेषलब्ध्या सहितानि पृथक् त्रयोदश गुणानि ।
अधिमास शेषलब्ध्या हीनानि पृथक् रविशशांकौ ॥ —*BrSpSi.* XIII. 20-22
विनाद्युराशेरपि चन्द्रभास्करौ प्रकुर्वतो वा विधिरेष कथ्यते ।
समासु मासीकृतविग्रहासु ये ह्यतीतमासा विनियोज्य तान् पुनः ॥
खरामनिघ्नान् दिवसेषु योजयेद् गतेषु मासस्य ततोऽधिमासकैः ।
निहत्य सर्वं विभजेत् सर्वदा युगार्कमासैर्दिवसत्वमागतैः ॥
भवन्ति लब्धास्त्वधिमासकाः पुनस्ततोऽपनीयाशु च भागहारकम् ।
भजेत शेषं शशिमास संख्यया ततोंऽशलिप्ता विकलाः स तत्पराः ॥
ततोऽधिमासान् प्रणिहत्य खाग्निभिर्नियोज्य सम्यग्गतवासरैः क्रमात् ।
युगावमघ्नाञ्छशिवासरैर्हरेत् तमत्र शेषं प्रवदन्ति चाह्निकम् ॥
हत्वाऽधिमासैरवमस्य शेषं छित्वा धराया दिवसैः प्रलब्धम् ।
संयोज्य नित्यं त्वधिमासशेषे कार्यं पुनस्तत् करणैर्यथोक्तम् ॥
युगप्रसिद्धैर्धरणी दिनैर्हरेन्निहत्य षष्ट्या यावमशेषमाह्निकम् ।
कलाविलिप्ताः क्रमशस्ततत्परास्त्वतीतमासा दिवसा गृहांशकाः ॥
त्रयोदशघ्नादपि रूपताडिताद्विशोधयेद्यत्त्वधिमासशेषजम् ।
निशाकरार्कौ गणकैः प्रकीर्तितौ भट प्रणीताविति बुद्धिमत्तमैः । —*MBh.* I. 13-19

(Here verse 17 should follow verse 15—*K.S. Shukla*)

K. S. Shukla has provided the following rationale to the rule cited above :

The fraction of the intercalary month (obtained in the rule) $= \dfrac{\text{adhimāsaśeṣa}}{\text{solar days in a } yuga}$, in mean lunar months.

$$= \frac{\text{adhimāsaśeṣa}}{\text{lunar days in a } yuga}, \text{ in mean solar months.} \qquad \text{(i)}$$

The fraction of the omitted lunar day (obtained in the rule)

$$= \frac{\text{avamaśeṣa or āhnika}}{\text{lunar days in a } yuga}, \text{ in mean civil days.}$$

$$= \frac{\text{avamaśeṣa}}{\text{civil days in a } yuga}, \text{ in mean lunar days.}$$

$$= \frac{\text{avamaśeṣa} \times 60}{\text{civil days in a } yuga}, \text{ in mean lunar } ghaṭis. \qquad \text{(ii)}$$

The fraction of the intercalary month corresponding to the above fraction of the omitted lunar day

$$= \frac{(\text{intercalary months in a yuga}) \times (\text{avamaśeṣa})}{(\text{lunar days in a } yuga) \times (\text{civil days in a } yuga)},$$

in mean solar months. (iii)

Adding (i) and (iii) and multiplying by 30, the total fraction of the intercalary month

$$= \left\{ \frac{\text{adhimāsaśeṣa}}{\text{lunar months in a } yuga} + \frac{(\text{intercalary months in a } yuga) \times (\text{avamaśeṣa})}{(\text{lunar months in a } yuga) \times (\text{civil days in a } yuga)} \right\}$$

in mean solar days, (iv)

Suppose that m lunar months and d lunar days have elapsed since the beginning of Caitra. Then, treating them as mean lunar months and mean lunar days, m months and d days denote the time elapsed since the beginning of mean Caitra up to the beginning of the current lunar day (treated as mean lunar day). As (ii) is the interval, in mean lunar *ghaṭis*, between the beginning of the current lunar day and the mean sunrise on that day, therefore

$$m \text{ months} + d \text{ days} + \text{(ii)}$$

denotes the time in mean lunar months, days, ghaṭīs[1] elapsed

1. 1 hour = 2½ ghaṭīs; 1 ghaṭī = 60 vighaṭīs; 1 vighaṭī = 60 pravighaṭīs.

since the beginning of mean Caitra up to the mean sunrise on the current lunar day.

Like wise

m months+d days+(ii) −(iv)

denotes the time in mean solar months, days, ghaṭīs etc. elapsed since the beginning of the current mean solar year up to the mean sunrise on the current lunar day[1].

Let M, D, G, V, and P denote respectively the mean solar months, mean solar days, mean solar ghaṭīs mean solar vighaṭīs and mean solar pravighaṭīs elapsed since the beginning of the current mean solar year up to the mean sunrise on the current lunar day. Then evidently mean longitude of the Sun

=M signs, D degrees, G minutes, V seconds and P thirds.

=(m signs and d degrees)+[minutes, seconds etc. corresponding to (ii)]−[degrees, minutes etc. corresponding to (iv)].

and mean longitude of the Moon

=13 [m signs and d degrees+(minutes, seconds, etc. corresponding to (ii)]−[degrees, minutes etc. corresponding to (iv)]

because

[(1/12) mean longitude of the Moon−mean longitude of the Sun.

=m signs+d degrees+(minutes, seconds etc. corresponding to (ii)]

(This equality is based on the fact that the left hand side denotes the mean lunar date also known as *madhyama tithi*).

A similar rule of these calculations of the mean longitude

1. Because (iv) is equal to fraction of a lunar month between the beginning of Caitra and the beginning of the current mean solar year fraction of an intercalary month corresponding to the tithis elapsed up to the beginning of the current mean lunar day since the beginning of Caitra fraction of an intercalary month corresponding to the avamaśeṣa, i.e., the lunar portion between the beginning of the current lunar date and the following sunrise.

of the Sun and the Moon without basing on *ahargaṇa* has also been given by Brahmagupta in the *Khaṇḍakhādyaka*[1].

Concordance of Working Rules

There has been a good deal of agreement on various rules of astronomical constants from the time of Āryabhaṭa I (499 A. D.) to the Bhāskara II (1150 A. D.) or even later to the days of Munīśvara (1620 A, D). Earliest concepts were formulated during the days of the Vedāṅga-Jyautiṣa and the Siddhāntas of Indian and the western origin, for example of Brahma, Vasiṣṭha, Pitāmaha, Romaka and Puliśa. We in this section are giving some important concordances which we find common in the writings of Brahmagupta and his predecessors, contemporaries and successors as listed below. The list is not exhaustive. Only a a few illustrations have been cited.

1. Ārya.—*Āryabhaṭīya*. Āryabhaṭa I, 499 A. D.
2. BrSpSi. —*Brāhmasphuṭasiddhānta*, Brahmagupta, 628 A. D.
3. K. K.—*Khaṇḍakhādyaka*, Brahmagupta, 628 A. D.
4. KKu.—*Karṇa-kutūhala*, Bhāskara II, 1150 A. D.
5. LBh.—*Laghu-Bhāskarīya*, Bhāskara I, 522 A. D.

   MBh.—*Mahā-Bhāskarīya*, Bhāskara I, 522 A. D.
   MSi.—*Mahā-siddhānta*, Āryabhaṭa II, 950 A. D.
   PSi.—*Pañcasiddhāntikā*, Varāhamihira, 505 A. D.
   ŚiDVṛ.—*Śiṣyadhīvṛddhida*, Lalla, 598 A. D.
   SiSā.—*Siddhāntasārvabhauma*, Munīśvara, 1620 A. D.
   SiŚe—*Siddhāntaśekhara*, Śripati, 1039 A. D.
   SiŚi.—*Siddhānta-Śiromaṇi*, Bhāskara II, 1150 A. D.
   SūSi.—*Sūryasiddhānta*, Modern, 6th or 7th Century.

1. Rule for finding the mean longitudes of the Sun, Mercury and Venus : *BrSpSi*. I. 44.

Also *MBh*. 1. 31. *MSi* I. 26 ; SiŚe II. 42, 43 ; *SiŚi*. I i, (d). 15 ; *SiSā* I. 105 ; *KKu* I. 7.

2. Rule for finding the mean longitude of the Moon's ascending node : *BrSpSi*, XXV. 35.

1. द्विनवरसभक्तभवमावशेषमाप्त दिनादि तत्सहितात् ।
अधिमासशेषकाच्च त्रिंशद् गुणिताद्दतुखदिग्भिः ॥
मासदिन प्रथमैक्यं पृथक् त्रयोदशगुणं द्वितीयोनौ ।
द्वाक्प्येवं मध्यौ राश्याद्य रविचन्द्रौ वा ॥ =*KK*. I. 11–12

Also *MBh.* I. 33 ; *ŚiDVṛ.* I. i. 52 (ii)

3. Rule for finding the mean longitude of the *Śīghrocca* of Venus and also giving the additives for the *Śīghrocca* of Mercury and Moon : *BrSpSi.* XXV. 36.

Also *MBh.* I. 35 ; *ŚiDVṛ.* I, i, 57 (ii)

4. Rule for finding the mean longitude of the *Śīghrocca* of Mercury : *BrSpSi.* XXV. 34.

Also *MBh.* I. 36 ; *ŚiDVṛ.* I. i. 50 (ii)

5. Rule for finding the mean longitude of Saturn : *BrSpSi.* XXV. 35.

Also *ŚiḌVṛ.* I. i. 52 (i) ; *MBh.* I. 37.

6. Rule for finding the mean longitude of Mars : *BrSpSi.* XXV. 33.

Also *ŚiDVṛ* I. i. 50 (i) *MBh.* I. 38.

7. Rule for finding the mean longitude of Jupiter : *BrSpSi.* XXX. 35.

Also *MBh.* I. 39 ; *ŚiDVṛ.* I. i. 51 (i).

8. Rule for finding the distance of a place from the prime meridian : *BrSpSi.* I. 36.

Also *MBh.* II. 3-4 ; *LBh.* I. 25-26 ; *ŚiDVṛ.* I. 57-58 (i) ; *SiSā.* I. 143-144.

9. Rule for finding the directions : *BrSpSi.* III. 1.

Also *MBh.* III. 2 ; *SūSi.* III. 1-4 ; *LBh.* III. 1; *SiDVṛ.* I. iii. 1 ; *MSi.* IV. 1-2 ; *SiŚe.* IV 1-3 ; *SiŚi.* I. iii. 8-9.

Alternative rule : *BrSpSi.* III. 2.

Also *MBh.* III. 3 ; *PSi.* XIV. 14-16 ; *ŚiDVṛ.* I. iii. 2 ; *SiŚe.* IV. 4.

10. Rule for finding the latitude and colatitude and the zenith distance and altitude of the Sun : *BrSpSi.* III. 10.

Also *MBh.* III 5; *SūSi* III. 13-14; *LBh.* III 2-3 *ŚiDVṛ* I. iii. 4-5 ; *SiŚe.* IV. 7; *SiŚi* I. iii. 18.

11. Rule for determining the declination, day—radius, earth sine and ascensional difference (for the Sun or a point on the ecliptic) : *BrSpSi.* II. 55.

Also *SūSi* II. 28 ; *LBh.* II. 16; . I. ii *ŚiDVṛ.* 17; *ṢiŚe.* III.

63-64 ; *SiŚi*. I. ii. 47 (ii) (For RSine of the Declination).

BrSpSi. II. 56 ; also *Ārya*. IV 24 ; *MBh*. III, 6; *LBh*. II. 17 ; *ŚiDVṛ*. I. ii. 18 ; *SiŚe*. III. 66 ; . *SiŚi* I. ii. 48 (For day-radius).

BrSpSi. II. 57-58 ; also *MBh*. III. 7 ; *LBh*. II. 18 ;

SūSi .II. 61; *ŚiDVṛ*. I. ii. 18 ; *SiŚe* III. 67 ; *SiŚi*. I. ii. 49 (i) (For the ascensional difference).

12. For finding the times of rising of the sāyana signs at the equator : *BrSpSi*. III. 15.

Also *MBh*. III. 9 ; *SūSi*. III. 42–43 : *ŚiDVṛ*. I. iii. 8 ; *SiŚe*. IV. 15 ; *SiŚi* I. 11. 51.

13. Rule for finding the ascensional differences of the Sāyana signs Aries. Taurus and Gemini : *KK*. 1. 21.

Also *MBh*. III. 8 ; *PSi*. III. 10 ; *ŚiDVṛ*. 1, XIII. 9 ; *SiŚi*. I. ii. 50-51.

14. Rule for the determination of the meridian zenith distance and meridian altitude of the Sun with the help of the Sun's declination and the latitude of the place ; *BrSpSi*. III, 47.

Also *MBh*. III. 11 ; *LBh*. III. 27 ; *ŚiDVṛ*. I. iii. 16 ;*SiŚe*. IV. 42.

15. Rule for determination of the latitude with the help of the Sun's meridian zenith distance and declination :

BrSpSi. : III. 13.

Also *MBh*. III. 17: *LBh*. III. 34; *SūSi*. III. 15-16; *SiŚe*. IV. 51,

16. Rule for finding out the Rsine of the Sun's altitude for the given time in *ghaṭīs* : *BrSpSi*. III. 25-26 Also *Ārya* IV. 28; *MBh*. III. 18-20; *LBh*. III. 7-10: *ŚiDVṛ*. I. iii. 24-25; *SiŚe*. IV. 32,34; *SiŚi*. I. iii. 53-54.

17. Rule for finding out the Sun's altitude : RSin $\alpha=$

$$\frac{M\times \text{day radius}}{R}\times\frac{\text{gnomon}}{\text{hypotenuse of equinoctial midday shadow}}$$

where M=R Sin (given *ghaṭīs*∓asc. diff.) Rsin (asc. diff.), the upper or lower sign being taken according as the Sun is the northern or southern hemisphere, α is the Sun's altitude. *BrSpSi*. III. 27 (i).

Also *MBh.* III 24; *ŚiDVṛ.* I. iii. 27; *SiŚe* IV. 37

18. Rule for finding the Sun's altitude when the Sun's ascensional difference is greater than the given time: *BrSpSi.* III. 33:

Also *MBh.* III 25, *LBh.* III. 11; *ŚiDVṛ.* I. iii. 29 *SiŚe.* IV. 41.

19. Rule for finding the Sun's altitude in the night: *BrSpSi.* III. 63.

Also *MBh.* III. 26; *LBh.* III. 11; *SiŚe.* IV. 89.

The Sun's altitude for the night has been called *Pātāla Śaṅku* by Brahmagupta (*BrSpSi.* XV.9)

20. Rule for finding the longitude of the rising point of the ecliptic with the help of (i) the instantaneous sāyana longitude of the Sun and (ii) the civil time measured since sunrise, or with the help of (i) the Sun's sāyana longitude at sunrise and (ii) the sidereal time elapsed since sunrise: *BrSpSi* III. 18-20.

Also *MBh.* III. 30-32: *LBh.* III. 17-19; *SūSi.* III. 46-48;
ŚiDVṛ. I. iii. 11-12: *SiŚe* IV. 18-19 (i): *SiŚi* I. iii. 2-4.

21. Rule for obtaining the civil time measured since sunrise with the help of (i) the Sun's instantaneous sāyana longitude and (ii) the sāyana longitude of the rising point of the ecliptic, or the sidereal time elapsed since sunrise with the help of (i) the Sun's sāyana longitude at sunrise and (ii) the sāyana longitude of the rising point of the ecliptic: *BrSpSi* III. 21-23.

Also *SūSi.* III.50-51; *MBh.* III. 34-36; *LBh.* III. 20;
ŚiDVṛ. I. iii. 13; *SiŚe* IV. 19 (ii)—22 (i); *SiŚi* I. iii. 5-7. (i).

22. Rule for determining the R Sines of the Sun's prime vertical altitude: *BrSpSi* III. 52.

Also *Ārya.* IV; *MBh.* III.37-38; *LBh.* III. 52.

(An error created by Āryabhaṭa has been criticised by Brahmagupta.)

23. Construction of the locus of the end of the shadow of a gnomon: *BrSpSi.* III. 2-3.

Also *MBh.* III 52; *ŚiDVṛ.* I. iii. 3; *SiŚe,* IV. 5;

24. Rule for finding the Sun's mean anomaly: *BrSpSi,* II. 12 (i).

Also *MBh.* IV. 1; *SūSi.* II. 29 ; *ŚiDVr* I. ii. 10; *SiŚe.* iii. 12; *SiŚi.* I. ii. 18-19 (i).

25. Rule for finding the RSine (Reversed sine) of an arc (<90°) : *BrSpSi* II. 10.

Also *SūSi.* II. 31-32 ; *MBh.* IV. 3-14; *LBh.* II, 2 (11)-3 (i); *ŚiDVr.* I. ii. 12 ; *SiŚe.* III. 15; *SiŚi.* I, ii. 10 (ii)-11.

(We shall discuss it separately in the light of Brahmagupta formula.)

26. Rule for finding the Sun's equation of the centre: *BrSpSi..* II. 15 (ii);

Also *MBh.* IV. 4 (ii); . III *SiŚe.* 27

27. Rule for determining the Sun's true longitude: *BrSpSi.* XIV. 17-18.

Also *MBh,* IV. 21-23; *SiŚe.* III. 52.

28. Rule for finding the Sun's *bhujāntara* correction under the eccentric theory : *BrSpSi.* XIV. 19.

Also *MBh.*-IV. 24.

29. Rule for determining the *cara-saṁskāra* or *cara* correction : *KK.* I. 22.

30. Rule for finding the semi-durations of the day and night : *BrSpSi.* II. 60 ; *KK.* I. 23.

Also *SuSi.* II. 62-63 ; *ŚiDVr,* I. ii. 20-21 ; *SiŚe.* III. 70 ; *SiŚi.* I. ii. 52.

31. Rule for calculating the *tithi* : *BrSpSi,* II. 62 ; *KK.* I. 25.

Also *SūSi.* II. 66 ; *ŚiDVr* I. ii. 22 ; *SiŚe.* III. 71 ; *SiŚi.* I. ii. 66.

32. Rule for calculating the *Karaṇa* : *KK.* I. 27.

Also. *ŚiḌVr.* I. ii. 24 ; *SiŚe.* III. 77 ; *SiŚi.* I. ii. 66.

33. Rule for calculating *nakṣatra* : *BrSpSi.* II. 62 ; *KK.* I. 24.

Also *SūSi.* II. 64 ; *ŚiDVr.* I. ii. 23 (i) ; *SiŚe.* III. 75; *SiŚi.* I. ii. 67.

34. Rule pertaining to direct and retrograde motions of a planet : *BrSpSi.* II. 50-51.

Also *MBh.* IV. 56-57 ; *SiŚe.* III. 59 ; *ŚiDVr.* I. ii. 42 ;

35. A rule for converting true distances known in minutes into true distances into yojanas : for example : Sun's true distance in yojanas

$$= \frac{\text{Sun's mean distance in } yojanas \times \text{Sun's true dist. in minutes}}{\text{Radius}}$$

BrSpSi. XXI. 31 (ii).

Also *MBh.* V. 3 ; *ŚiDVr.* I. iv. 5 (i) ; *LBh.* IV. 3 ; *SiŚe.* V. 4 (ii) ; *SiŚi* I.v. 5 (i) ;

36. Rule for finding angular diameters of the Sun and the Moon : *BrSpSi.* XXI. 34 (ii) ;

Also *MBh.* V. 5 : *ŚiDVr.* I. iv. 8 ; *SiŚe.* V. 6 ; *SiŚi.* I. v. 7,

37. Formulae for the true (i. e. angular) diameters of the Sun, the Moon and the shadow in terms of the true daily motions of the Sun and the Moon (Here by shadow is meant the section of the cone of the Earth's shadow at the Moon's distance.) : *BrSpSi.* IV. 6 (i) : *KK.* IV. 2 (i).

Also *MBh.* V. 6–7 ; *ŚiDVr.* I. iv. 9 ; *MSi.* V. 5 (ii) ;
SiŚe V. 9 ; *SiŚi.* I. v. 8-9 ;

38. Rule for finding the *spaṣṭa-valana* (resultant *valana*) for the circle drawn with half the sum of the diameters of the eclipsed and eclipsing bodies as radius : *BrSpS..* IV. 18 (i).

Also *MBh.* V. 46 ; *ŚiDVr.* I. iv. 26.

39. Method for calculating the phase of the eclipse for the given time : *BrSpSi.* IV. 11-12.

Also *MBh.* V. 62-63 ; *ŚiDVr.* I. iv. 19-20 ; *SiŚe.* V. 14.

40. Rule for the determination of the diameter of the shadow i.e., the diameter of the Section of the Earth's shadow where the Moon crosses it : *BrSpSi.* XXIII. 8-9.

Also *MBh.* V. 71-73 ; *Āryc.* IV. 39-40 ; *ŚiDVr.* I. iv. 6 (ii)-7.

41. Process of successive approximations in connection with calculations of a lunar eclipse : *BrSpSi.* IV. 8-9.

Also *MBh.* V. 75-76 ; *LBh.* IV. 10-12 ; *ŚiDVr.* I. iv. 14-16 *SiŚe.* V. 12-13; *SiŚi.* I, v. 12-13.

42. Rule relating to the visibility-correction known as *akṣa-dṛkkarma* : *BrSpSi*. VI. 4.

Also *MBh*. VI. 1-2 ; *ŚiDVṛ*. I. vii. 3 (ii) ; *MSi*. VII. 4 ; *SiŚe*. IX. 7.

43. Rule relating to the visibility correction known as *ayanadṛkkarma* : *BrSpSi*. VI. 3 ; X. 17.

> Slightly modified in *MBh*. VI. 2 (ii)-3 ; *ŚiDVṛ*. I. vii. 2-3 (i) · *SiŚe*. IX. 4-5 ; similar in *MSi*. VII. 2-3 ; more accurate in *SiŚi*. I. viii. 4-5.

44. Rule relating to the visibilily of moon : *BrSpSi*. VI. 6 ; X. 32.

Also *MBh*; VI. 4-5 (i) *PSi*. V. 3 : *ŚiDVṛ*. I. vii. 5 ; *SiŚe*. IX. 8 (i). 13.

45. Rule for calculating the phase of the Moon : *BrSpSi*. VII. 11 (ii)-12.

Also *MBh*. VI. 5 (ii)-7 ; *ŚiDVṛ*. I. ix. 12.

46. Rule for the determination of the Moon's true declination (i.e. the declination of the centre of the Moon's disc) : *BrSpSi*. VII. 5.

Also *MBh*. VI. 8 ; *ŚiDVṛ*. I. viii. 2 ; *SiŚe*. X. 7. (these are approximate rules ; a more accurate rule occurs in *SiŚi*. I. vii. 3 and 13).

47. Graphical representation of the elevation of the lunar horns in the first quarter of the month at sunset : *BrSpSi*. VII. 7-10.

Also *MBh*. VI. 13-17 ; *ŚiDV*. I. ix ; *SiŚi*. I. ix.

48. Minimum distances of the planets from the Sun when they are visible : *BrSpSi*. vi 6 ; X. 32.

Also *MBh*. VI. 44 ; *ŚiDVṛ*. I. vii. 5 (i) ; *SiŚe*. IX. 8 (i). 12.

49. Rule relating to the determination of the time and the common longitude of two planets when they are in conjunction in longitude : *BrSpSi*. IX. 5-6.

Also *MBh*. VI. 49-51 ; *ŚiDVṛ*. I. x. 7-9 (i) ; *SiŚe*. XI. 12-12.

50. Rule relating to the distance between two planets

which are in conjunction in longitude : *BrSpSi*. IX. 11.

Also *MBh*. VI. 54 ; *ŚiDVṛ*. I. x. 11 ; *SiŚe*. XI. 10.

51. Rule For finding the *Bhujaphala* and *Koṭiphala* etc. without the use of the RSine-difference table : *BrSpSi*. XIV. 23-24.

Also *MBh*. VII, 17-19 ; *SiŚe*. III. 17.

52. To obtain the Sun's mean true longitude derived from the midday shadow of the gnomon : *BrSpSi*. XIV. 28; III. 61-62.

Also *MBh*. VIII. 5; *SiŚi* I. ii. 45.

53. Rule to find the arc corresponding to a given RSine : *BrSpSi* II. 11.

Also *MBh*. VIII. 6; *SūSi*. II. 33, *ŚiDVṛ*. I. ii. 13, *SiŚe*. III. 16, *SiŚi*. I. ii. 11 (ii)—12 (i).

For the concordance given here we express our indebtedness to the work of K.S. Shukla on the *Mahābhāskarīya*.

Tables of Constants

Some of the Tables of Constants have been given in an earlier chapter. We here give a few more tables which would indicate how far Brahmagupta introduced new concepts in evaluating these constants of greater accuracy and refinement.

TABLE I

Position of Planets for the Beginning of *kaliyuga*

In this Table are given the positions of the planets, including the Moon's apogee and ascending node, for the beginning of *Kaliyuga*. The calculations of Brahmagupta are different from those of the *Sūryasiddhānta* and of Āryabhaṭa I,

Planet	Positions *BrSpSi.*	according *Ārya.*	to *SūSi*
1	2	3	4
	s ° ′ ″	s ° ′ ″	s ° ′ °
Sun	0 0 0 0	0 0 0 0	0 0 0 0
Moon	0 0 0 0	0 0 0 0	0 0 0 0

1	2	3	4
	s ° ′ ″	s ° ′ ″	s ° ′ ″
Moon's apogee	4 5 29 46	3 0 0 0	3 0 0 0
Moon's asc. node	5 3 12 58	6 0 0 0	6 0 0 0
Mars	11 29 3 50	0 0 0 0	6 0 0 0
Mercury	11 27 24 29	0 0 0 0	0 0 0 0
Jupiter	11 29 27 36	0 0 0 0	0 0 0 0
Venus	11 28 42 14	0 0 0 0	0 0 0 0
Saturn	11 28 46 34	0 0 0 0	0 0 0 0

TABLE II

Diameters of the Sun, the Moon and the Earth in *yojanas* and the distances of the Sun and the Moon from the Earth

	BrSpSi	Bhāskara I	Śrīpati	Bhāskara II	Modern (in miles)
1	2	3	4	5	6
Sun's diameter in *yojanas*	6,522	4,410	6,522	6,522	86,400
Sun's distance in *yojanas* (mid-night reck.)	689,358	459,585	684,870	689,377	92,900,000
Ratio		0·009596	0,009,523	009,461	00,093
Moon's diameter in *yojanas*	480	315	480	400	2,160
Moon's distance in *yojanas* (mid-night reck.)	51,566	34,377	51,566	51,566	2,389,000
Ratio Earth's diameter in *yojanas*	1,581	0,009,163	0,009,308	009,308	0,009

TABLE III

Sidereal Revolutions of the Apogees of the Planets in a Kalpa

Apogee of	*BrSpSi.*	According to *Sūrya-Siddhānta*	*Āryabhaṭīya*
1	2	3	4
Sun	480	387	not given
Mars	292	204	
Mercury	332	368	
Jupiter	855	900	
Venus	653	535	
Saturn	41	39	

TABLE IV

Sidereal Revolutions of the Nodes of the Planets in a Kalpa

(Not given in the *Āryabhaṭīya*)		*Sūrya-Siddhānta*
Node of	*BrSpSi.*	
1	2	3
Mars	267	214
Mercury	521	488
Jupiter	63	174
Venus	893	903
Saturn	584	662

TABLE V

Peripheries of the Epicycles of the Planets

Planet	*BrSpSi.*		*Sūrya-Siddhānta*		*Āryabhaṭīya*	
	odd quad.	even quad.	odd quad.	even quad.	odd quad.	even quad.
1	2		3		4	

(a) *Manda* epicycles

Sun	13°40′		13°40′	14°	13°30′	
Moon	31°36′		31°40′	32°	31°30′	
Mars	70°		72°	75°	63°	81°
Mercury	38°		28°	30°	31°30′	22°30′
Jupiter	33°		32°	33°	31°30′	36°
Venus	9°	11°	11°	12°	18°	9°
Saturn	30°		48°	49°	40°30′	58°30′

(b) *Śīghra* epicycles

1	2		3		4	
Mars	243°40′[1]		232°	235°	238°30′	229°30′
Mercury	132°		132°	133°	139°30′	130°30′
Jupiter	68°		72°	70°	72°	67°30′
Venus	263°	258°	260°	262°	265°30′	256°30′
Saturn	35°		40°	39°	40°30′	36°

1. In the middle of quadrants, it is 237°

TABLE VI

Mean Diameters of the Planets

Planet	*BrSpSi.*	*Sūrya-Siddhānta*	*Āryabhaṭīya*	Modern
1	2	3	4	5
Sun	32′31″	32′24″	33′ approx.	32′2′36″
Moon	32′ 1″ approx.	32′	31′30″	31′8″
Mars	4′46″	2′	1′17″	9′36″
Mercury	6′14″	3′	2′8″	6′68″
Jupiter	7′22″	3′30″	3′12″	3′14.72″
Venus	9′	4′	6′24″	16.8″
Saturn	5′24″	2′30″	1′36″	2′49.5″

TABLE VII

Inclination of the Orbits of the Planets to the Ecliptic

Planet	*BrSpSi.*	*Sūrya-Siddhānta*	*Āryabhaṭīya*	Modern (Jan.00,195°)
1	2	3	4	5
Moon	4°30′	4°30′	4°30′	5°8′40″
Mars	1°50′	1°30′	1°30′	1°51′0″
Mercury	2°32′	2°	2°	7°0′14″
Jupiter	1°16′	1°	1°	1°18′21″
Venus	2°16′	2°	2°	2°23′39″
Saturn	2°10′	2°	2°	2°29′25″

TABLE VIII

Longitudes of the Junction Stars according to Different Authorities

Junction-star of	Longitude (polar) according to		Longitude according to		
	BrSpSi.KK. SiŚi.	*SiŚe.SūSi*	*MBh.*	*LBh.*	*SiDVṛ.*
1	2	3	4	5	6
Aśvinī	8°	8°	8°	8°	8°
Bharaṇī	20°	20°	27°	26°30°	20°
Kṛttikā	37°28′	37°30′	36°	36°	36°
Rohiṇī	49°28′	49°30′	49°	50°	49°
Mṛgaśirā	63°	63°	62°	62°	62°
Ārdrā	67°	67°20′	70°	70°	70°
Punarvasū	93°	93°	92°	92°	92°
Puṣya	106°	106°	105°	105°	105°
Āśleṣā	108°	109°	114°	114°	114°
Maghā	129°	129°	128°30′	128°30′	128°
P-Phālgunī	147°	144°	141°	141°	139°20′
U-Phālgunī	155°	155°	154°	154°	154°
Hasta	170°	170°	173°	173°	173°
Citrā	183°	180°	185°	185°	184°20′
Svāti	199°	199°	197°	197°	197°
Viśākhā	212°5′	213°	212°	212°	212°
Anurādhā	224°5′	224°	222°	222°	222°
Jyeṣṭhā	229°5′	229°	228°	228°	228°
Mūla	241°	241°	241°	241°30′	241°
P-Āṣāḍhā	254°	254°	254°	254°30′	254°

1	2	3	4	5	6
U-Āṣāḍhā	260°	260°	267°	266°30′	267°20′
Śravaṇa	278°	280°	285°	284°30′	284°10′
Dhaniṣṭhā	290°	290°	296°	295°30′	296°20′
Śatabhiṣak	320°	320°	307°	307°	313°20′
P-Bhādra.	326°	326°	328°	328°	327°
U-Bhādra	337°	337°	345°	345°	335°20′
Revatī	0°	359°50′	360°	360°	359°

TABLE IX

Celestial Latitudes of the Junction-Stars

Junction star of	Polar latitude given in			Latitude given in		
	BrSpSi.KK. SiSe.	*SūSi.*	*SiŚi*	*MBh.*	*LBh.*	*ŚiDVr.*
1	2	3	4	5	6	7
Aśvinī	10°*N*	10°*N*	10°*N*	10°*N*	10°*N*	10°*N*
Bharaṇī	12°*N*	12°*N*	12°*N*	12°*N*	12°*N*	12°*N*
Kṛttikā	4°31′*N*	5°*N*	4°30′*N*	5°*N*	5°*N*	5°*N*
Rohiṇī	4°33′*S*	5°*S*	4°30′*S*	5°*S*	5°*S*	5°*S*
Mṛgaśirī	10°*S*	10°*S*	10°*S*	10°*S*	10°*S*	10°*S*
Ārdrā	9°*S*	9°*S*	9°*S*	9°*S*	9°*S*	9°*S*
Punarvasū	6°*N*	6°*N*	6°*N*	6°*N*	6°*N*	6°*N*
Puṣya	0	0	0	0	0	0
Āśleṣā	7°*S*	7°*S*	7°*S*	7°*S*	7°*S*	7°*S*
Maghā	0	0	0	0	0	0
P-Phālgunī	12°*N*	12°*N*	12°*N*	12°*N*	12°*N*	12°*N*
U-Phālguni	13°*N*	13°*N*	13°*N*	13°*N*	13°*N*	13°*N*

1	2	3
Hasta	11°S	11°S
Citrā	1°45′S	2°S
Svāti	37°N	37°N
Viśākhā	1°23′S	1°30′S
Anurādhā	1°44′S	3°S
Jyeṣṭhā	3°30′S	4°S
Mūla	8°30′S	9°S
P-Āṣāḍhā	5°20′S	5°30′S
U-Āṣāḍhā	5°S	5°S
Śravaṇa	30°N	30°N
Dhaniṣṭhā	36°N	36°N
Śatabhiṣak	18′S	30′S
P-Bhādra	24°N	24°N
U-Bhādra	26°N	26°N
Revatī	0	0

backing to the west) in one day. It is sufficient to postulate the existence of only one Sun, one Moon and twenty-seven nakṣatras to explain the astronomical phenomena.[1]

3. Brahmagupta differs from Āryabhaṭa I in the length of the four *yugas*. Ārvabhaṭa regards all the four *yugas* of equal lengths, i. e. 1,080,000 years; the *caturyuga* being of 4,320,000 years. Brahmagupta regards *Kaliyuga* to be of 432,000 years, *Dvāpara* to be twice of it, *Tretā* to be thrice of it and *Kṛtayuga* of four times of the length of the *Kaliyuga*. Both have the *caturyuga* of the same length.[2]

4. Āryabhaṭa was not clear with respect to the number of civil days (*sāvana dina*) in a *yuga*; in one of his treatises he gives this number to be 1,577,917,800 and in the other 1,577,917,500 with a difference of 300 days. though in both the treatises, Āryabhaṭa I regards the number of solar years to be 4,320,000 in a *Caturyuga* or *Mahāyuga*. Why is this difference ? asks Brahmagupta.[3]

5. Āryabhaṭa regards *mandocca* (the apogee) and *pāta* (the ascending node of the orbit on the ecliptic) as constant or stationary; then how could he propound a *sphuṭa-yuga* or the concept of true *yuga* with the concurrence of year, month and day on the Caitra Śukla Pratipadā (the first day of bright half of the month Caitra) at the same time as indicated by Āryabhaṭa in his *Laghvāryabhaṭīya Tantra*.[4]

Āryabhaṭa was not clear in respect to the variance in the pāta. In the Āryāṣṭa-śata (in the Aryabhaṭīva which has 108 Āryā verses), Āryabhaṭa states that the *pāta* of all the planets

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1. भानिचतुस्पञ्चाशद्द्वौ द्वावर्केन्दवौ जिनोक्तं यत् ।
ध्रुवमत्स्यस्यावर्त्तौ भवति यतोऽन्हा ततस्तदसत् ॥ — *BrSpSi*. XI. 3

2. आर्यभटोयुगपादांस्त्रीन् यातानाह कलियुगादौ यत् ।
तस्यकृतान्तर्यस्मात् स्वयुगाद्यन्तौ न तत् तस्मात् ॥ —*BrSpSi*. XI. 4

3. युगरविभगणाः ख्युघ्रिति यत्प्रोक्तं तत् तयोर्युगं स्पष्टम् ।
त्रिशती स्युदयानां तदन्तरं हेतुना केन ॥ —*BrSpSi*. XI. 5

4. युगवर्षादीन् वदताचैत्रसितादेः समं प्रवृत्तान् यत् ।
तदसत् यतः स्फुटयुगं तत् स्थैर्यान्मन्दपातानाम् ॥ —*BrSpSi*. XI. 6

show variance of movement, but in the Daśagītikā (a chapter of ten Āryā verses), he states that with the exception of the *pāta* of the *Moon*, the *pāta's* of all other planets are stationary or constant. Brahmagupta points out this anomaly in the concept of Āryabhaṭa.[1]

6. Brahmagupta points out a self-contradiction in Āryabhaṭa. At one place he says that the Moon covers the Sun during the solar eclipse and similarly the shadow of the Earth covers the Moon during the lunar eclipse (and he does not mention Rāhu) in this connection (*Āryabhaṭīya*, Gola. 37). At the same time it is said that Āryabhaṭa was familar with the movement of "*eight*" planets, and thus postulating the presence of Rāhu; in fact, the *pātas* of planets are responsible for their eclipse, and the eighth planet Rāhu is not present.[2]

7. Āryabhaṭa gives measures to Manus. Yugas and Kalpas different from what have been given in the recognised *Smṛtis*.[3]

8. Āryabhaṭa regards *Guruvāra* or Thursday to be the first day of the *Kalpa*, and not Sunday, which is wrong according to Brahmagupta.[4]

9. Brahmagupta unnecessarily criticises Āryabhaṭa in respect to the order of days. The motion of the planets decreases in the following order : Moon, *Budha* (Mercury), *Śukra* (Venus), Sun, *Kuja* (Mars), *Guru* (Jupiter) and *Śani* (Saturn). Āryabhaṭa in one of his verses states that starting from the Sun and proceeding in the increasing order every fourth is the *dinapati* or the "lord of the day" (*Āryabhaṭīya*, Kāla. 16) ; this gives the order : Sun, Moon. Mars, Mercury, Venus and Saturn and hence the order of days as *Ravivāra* (Sunday); *Candravāra* (Monday,)

1. आर्य्याष्टशते पाता भ्रमन्ति दशगीतिके स्थिराः पाताः ।
मुक्त्वेन्दु पातमपमण्डले भ्रमन्ति स्थिरा नातः ॥ —*BrSpSi*. XI. 8

2. आर्यभटो जानाति ग्रहाष्टगतिं यदुक्तवांस्तदसत् ।
राहुकृतं न ग्रहणं तत्पातो नाष्टमो राहुः ॥ —*BrSpSi*. XI. 9

3. समामनुयुगकल्पाः कल्पादिगतं कृतादियातं च ।
स्मृत्युक्तैरार्यभटो नातो जानाति मध्यगतिम् ॥ —*BrSpSi*. XI. 10

4. ओङ्कारो दिनवारो गुरुरौदयिकोऽस्य भवति कल्पादौ ।
न भवत्यर्को यस्मादोङ्कारो विस्तरस्तस्मात् ॥ —*BrSpSi*. XI. 11

Mangalavāra (Tuesday), (*Budhavāra*) (Wednesday), *Guruvāra* (Thursday) Sukravāra (Friday) and Śanivāra (Saturday). Thus Āryabhaṭa gives the same order of days as other authorities and there is no reason why he should be criticised.

Certainly what is Sunday for Laṅkā, may not be Sunday at the same time for Siddhapura; and Āryabhaṭa should have emphasised that the day (Monday, Tuesday etc.) is not constant for all the places.[1]

10. Brahmagupta expresses surprise why Āryabhaṭa, in two of his treatises propounds two different systems of reckoning one from the Sunrise in Laṅkā and the other from the Midnight in Laṅkā.[2] This causes a difference of one-fourth of the daily-motion in the two reckonings of the motion of planets.[3]

11. Brahmagupta criticises Āryabhaṭa on the point of diameter of the Earth. In the *Gītikāpāda*, 5 and 6, Āryabhaṭa states that one yojana=8,000 × puruṣa, and 1 puruṣa=4 hasta, thus 1 yojana=32,000 puruṣas, and the diameter of the Earth is 1050 yojanas. Brahmagupta further says that an error in the diameter of the Earth would cause an error in deśāntara or longitude and thus also in the true *tithi* and consequently in the calculation of eclipses also.[4]

12. Āryabhaṭa has rightly stated that the Earth is in motion and the *Bhagaṇas* are stationary. Brahmagupta's objection is that if the Earth is in motion, birds would not be able to return to their nests, and if the Earth's motion is upside-down,

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1. सूर्य्योदयश्चतुर्थो दिनवारा यदुवाच तदसदार्यभटः ।
लङ्कोदयो यतोऽर्कं स्यात्तमयं प्राह सिद्धपुरे ॥ —*BrSpSi*. XI. 12

2. अधिकैः शतैश्चतुर्भिर्वर्षसहस्रैश्चतुर्दशभिरेकः ।
युगपादे दिनवारान्तर मौदयिकार्धरात्रिकयोः ॥ —*BrSpSi*. XI. 13.

3. औदयिकाद्दिनभुक्तेस्तुर्यांशो नार्धरात्रिको भवत्यूनः ।
कतरं स्फुटं न निश्चितमनयोः स्फुटमेकमपि नातः ॥ —*BrSpSi*. XI. 14

4. षोडशगाक्योजनरिधिं प्रतिभूव्यासं पुलावदता ।
आत्मज्ञानं स्यात्पितमनिश्चयस्तनि कृतकन्यात् ॥
भूव्यासस्याज्ञानाद् व्यर्थं देशान्तरं तदज्ञानात् ।
स्फुटतिथ्यज्ञानं तिथिनाशाद् ग्रहणयोर्नाशः ॥ —*BrSpSi*. XI. 15-16

then the roof and hills would come down, which is contrary to our observation.[1] Obviously Brahmagupta is not justified in his criticism.

13. Brahmagupta points out to the differences in his calculations and the calculations of Āryabhaṭa in the peripheries of the *manda* and *śīghra* epicycles of planets in the odd and even quadrants. (This difference we have shown in Table V, p. 313)[2]

14. Āryabhaṭa I and Bhāskara I have both given a rule for the determination of the *dṛkkṣepajyās* of the Sun and the Moon :

> Take the product of the Sun's or Moon's own *madhyajyā* and *udayajyā*, then divide the product by the radius and then take the square of the quotient. Subtract that from the square of the own *madhyajyā*; the square-root of that difference is known as the Sun's or Moon's *dṛkkṣepajyā*.[3]

The Sun's *dṛkkṣepajyā* is the Rsine of the zenith distance of that point of the ecliptic which is at the shortest distance from the zenith (this point is called nonagesimal or the central ecliptic point). The Moon's dṛkkṣepajyā is the Rsine of the zenith distance of that point of the Moon's orbit which is at the shortest distance from the zenith. The rule given above is only approximate and has been criticised by Brahmagupta.[4]

15. In the *Āryabhaṭīya*, there is a rule in the Golapāda for finding the Rsine of the *agra* of the true Sun; and also for the

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1. प्राणेनैति कलां भूर्यदि तर्हि कुतो व्रजेत् कमध्वानम् ।
आवर्त्तनमुर्व्याश्चेन्न पतन्ति समुच्छ्रयाः कस्मात् ॥ —*BrSpSi*. XI. 17

2. औदयिको यः परिधिर्विषमेऽन्योमेऽन्यः समे भुजस्य गुणः ।
तदसद्विषमान्तफलं यतो न युग्मादि फलतुल्यम् ॥
विषमेऽन्योऽन्यो युग्मे परिधिगुणकः क्रमोत्क्रमज्यानाम् ।
चक्रार्धे फलनाशो न भवति यस्मादसत् तदपि । —*BrSpSi*. *XI*. 18-19

3. स्वमध्यज्योदयाभ्यासं विष्कम्भार्धाप्तवर्गितम् ॥
मध्यज्यावर्गतोऽपास्य स्वदृक् क्षेपं पदं विदुः ॥ —*Mbh*. *V*. 19

4. वित्रिभलग्ने दृक्क्षेपमण्डलं तदपमण्डलयुतौ ज्या ।
मध्यादृक्क्षेपज्या नार्यभटोक्ताऽनया तुल्या ॥
दृक्क्षेपज्याऽतोऽसत् तन्नाशादवनतेर्नाशः ।
अवनतिनाशात् ग्रासस्योनाधिकता रविग्रहणे ॥ —*BrSpSi*. XI. 29-30

Rsine of the Sun's prime vertical altitude.[1] Bhāskara also gives the rule in his *Mahābhāskarīya* :

> Multiply the Rsine of the (Sun's) greatest declination by the Rsine of the Sun's true (*sāyana*) longitude; then divide (the product) by the Rsine of the colatitude, the result is (the Rsine of) the *agra* of the true Sun. When that (*agra*) is less than the latitude and when the Sun is also in the northern hemisphere, multiply (the Rsine of the Sun's *agra*) by (the Rsine of) the colatitude; the result is the Rsine of the Sun's prime vertical altitude.[2]

The condition laid down in the rule that the "Sun's *agra* should be less than the latitude" is incorrect. The error was originally comitted by Āryabhaṭa and Bhāskara followed it. This error was noticed by Brahmagupta[3]. Bhāskara I, however, corrected the error in the *Laghu-Bhāskarīya*. There he gives the correct conditions. It is not the *agra* that should be less than the latitude, it is the Sun's declination (or rather the Rsine of the Sun's northern declination as we have in the *Laghu-Bhāskarīya*), which should be less than the latitude (or rather the Rsine of the latitude). This condition is necessary for the existence of the prime vertical shadow of the gnomon.

It may be pointed out that the commentators of Āryabhaṭa I have interpreted the rule given by Āryabhaṭa I as conveying the correct meaning; they say that Āryabhaṭa also meant declination when he used the term *agra*.

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1. परमापक्रमजीवामिष्टज्यार्धाहतां ततो विभजेत् ।
ज्यालम्बकेन लब्धार्काग्रा पूर्वापरे क्षितिजे ॥
सा विषुवज्ज्योना चेद् विषुवदुदग्लम्बकेन संगुणिता ।
विषुवज्ज्यया विभक्ता लब्धः पूर्वापरे शंकुः ॥ —*Ārya*. V. 30-31

2. स्फुटरविभुजनिघ्नां यां परां क्रांतिजीवां ।
हरतु समवलम्बज्या कलापेन भूयः ॥
स्फुट दिवस कराग्रा सा यदाऽक्षांशहीना ।
रविरपि यदिगोले चोत्तरे लम्बकघ्नाम् ॥
अग्रज्यया हरेद् भूयः शंकुः स्यात् सममण्डले ।
तद् वर्गं व्यास कृत्योर्यद् विश्लेषं तत्पदं प्रभा ॥ —*MBh*. III. 37-38

3. चरगोलेऽग्रायां विषुवज्ज्यातो यदुक्तमूनायाम् ।
सममण्डलमस्तदसत् क्रान्तिज्यायां यतो भवति ॥ —*BrSpSi*. XI. 22

Usually by *agra*, we mean the arc of the celestial horizon lying between the east point and the point where a heavenly body rises ; or between the west point and the point where a heavenly body sets. Declination is *krānti*.

16. Brahmagupta has criticised Āryabhaṭa and his group for their expressions for determining *lambana* (i. e. the difference of the parallaxes, in longitude, of the Sun and the Moon), and the rule for determining the *avanati* or *nati* (i.e. the difference in parallaxes, in latitude of the Sun and Moon).[1]

Lambana is obtained with the help of the five Rsines : (i) *madhya-jyā*, (ii) *udaya-jyā*, (iii) *dṛk-kṣepa-jyā*, (iv) *dṛg-jyā*, and (v) *dṛg-gati-jyā*.

(i) The *madhyajyā* is the Rsine of the zenith distance of meridian ecliptic point :

madhyajyā=Rsin ($\phi \pm$ declination of the meridian ecliptic point).[2]

In this expression ϕ is the latitude of the place, and by R sin is meant R × sine, R being the radius of the celestial sphere.

(ii) The *udayajyā* is the Rsine of the arc of the horizon intervening between the equator and the ecliptic, and is given by :

$$udayajy\bar{a} = \frac{R \sin L \times R \sin \varepsilon}{R \cos \phi}$$

where L is the longitude of the horizon ecliptic point in the east and ε the obliquity of the ecliptic.

(iii) The *dṛkksepajyā* is the R sine of the zenith distance of the central ecliptic point[3], and is given by :

1. व्यासार्धेन विभक्ता दृग्नति जीवा चतुर्गुणा लब्धम् ।
लम्बननाड्यः पञ्चदशगुणितया त्रिज्यया भक्ता ॥
दृक्क्षेपज्या भुक्त्यन्तराहता लब्धमवनतिर्भवति ।
स्फुटयोजनकर्णाभ्यां भूव्यासेन च विना स्पष्टे ॥
आर्यभटेनास्मिन् सति लघुनि किमर्थं महत् कृतं कर्म ।
गणिता ज्ञानाज्जाड्यं विजानता यदि ततः सुतराम् ॥ —*BrSpSi*. XI. 23-25

2. The meridian ecliptic point is the point of the ecliptic on the meridian.

3. The central ecliptic point is the central point of the portion of the ecliptic lying above the horizon.

dṛkkṣepajyā

$$= \left[(madhyajy\bar{a})^2 - \left\{ \frac{udayajy\bar{a} \times madhyajy\bar{a}}{R} \right\}^2 \right]^{\frac{1}{2}}$$

where R is the radius of the celestial sphere.

(iv) The *dṛgjyā* is the Rsine of the zenith distance (of the Sun) and is given by :

$$dṛgjy\bar{a} = \left[R^2 - \left\{ \frac{dṛggatijy\bar{a} \times R \sin (L - \theta)}{R} \right\} \right]^{\frac{1}{2}}$$

where L is the longitude of the horizon ecliptic in the east and θ the longitude of the Sun.

(v) The *dṛggatijyā* is the Rsine of the altitude of the central ecliptic point, and is given by :

$$dṛggatijy\bar{a} = [R^2 - (dṛkkṣepajy\bar{a})^2]^{1/2}$$

where R is the radius of the celestial sphere.

In the *Mahābhāskarīya*[1], the expression for the Sun's *dṛggatijyā* is :

$$(\text{Sun's } dṛggatijy\bar{a})^2$$

$$= (\text{Sun's } dṛgjy\bar{a})^2 - (\text{Sun's } dṛkkṣepajy\bar{a})^2$$

and similar is the expression for the the Moon's *dṛggatjyā*.

Now *lambana*, which is the difference of the parallaxes, in longitude, of the Sun and the Moon, is given by the expression :

Lambana = Moon's *lambana* − Sun's *lambana*.

Sun's *lambana*

$$= \frac{\text{Sun's } dṛggatijy\bar{a} \times \text{Earth's semidiameter}}{\text{Sun's true distance in yojanas}}$$

Moon's *lambana*

$$= \frac{\text{Moon's } dṛggatijy\bar{a} \times \text{Earth's semi-diameter}}{\text{Moon's true distance in yojanas}}$$

These *lambanas* are in terms of minutes of arc etc[2].

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1. स्वदृग्ज्ये प गुणयोर्वर्गं विश्लेषजे पदे ।
दृग्गतिज्ये भवेतां ते भास्करामृत तेजसः ॥ —*MBh. V*, 23

2. स्वदृग्गतिज्या व्यास भेद संवर्ग संभवम् ।
कुभ्रमयोजनं कर्णाप्तं लिप्ताद्यं लम्बनं विदुः ॥

(Cont. on Page 225)

Thus *lambana* is given by subtracting the Sun's *lambana* from Moon's *lambana.*

This *lambana* is also expressed in the following way.

Lambana

$$= \left[\frac{\{(d\dot{r}gjy\bar{a})^2-(d\dot{r}kk\d{s}epajy\bar{a})^2\}^{1/2}\times 18}{\text{Moon's true distance}} - \frac{\{(d\dot{r}gjy\bar{a})^2-(d\dot{r}kk\d{s}epajy\bar{a})^2\}^{1/2}\times 18}{\text{Sun's true distance}} \right]$$

in minutes.

$= \frac{60}{d} \times$ (*lambana* calculated in minutes) is the *lambana* in *ghaṭīs*, where *d* denotes the difference between the daily motions of the Sun and the Moon.

Āryabhaṭa I has given his description of the determination of *lambana* and *avanati* in the Golapāda 33, 34 of the *Āryabhaṭīya*[1], and Bhāskara has followed his rules in the *Mahābhāskarīya*[2]. Brahmagupta criticises them in his *Brāhmasphuṭasiddhānta*[3].

(vii) We shall now take up *nati* or *avanati* (both the terms mean the same). *Nati* is the difference of the parallaxes in *latitude*, of the Sun and the Moon and is given by :

$$nati = \left[\frac{d\dot{r}kk\d{s}epajy\bar{a}\times 18}{\text{Moon's true dist.}} - \frac{d\dot{r}kk\d{s}epajy\bar{a}\times 18}{\text{Sun's true dist.}} \right]$$

minutes.

(Cont. from Page 324)

तद्विशेषो हतः षष्ट्या स्फुटभुक्त्यन्तरोद्धृतः ।
घटिकादिस्तिथेः प्राहणे शुद्धिः क्षेपोऽपरे मतः ॥
दिनार्धकालनिष्पन्नं लम्बनं शोध्यते तिथेः ।
उदगिन्दूदयज्यायां दीयते तत्र दक्षिणे ॥
एवं पुनः पुनः कर्म यावत्तदविशिष्यते ।
तिथिवच्चन्द्रतीक्ष्णांशू सञ्चार्यावेव पण्डितैः ॥ —*MBh.* V. 24-27

1. मध्यज्योदयजीवासंवर्गे व्यासदलहृते यत् स्यात् ।
तन्मध्यज्याकृत्योर्विशेषमूलं स्वदृक्क्षेपः ॥
दृग्दृक्क्षेप कृति विशेषितस्यमूलं स्वदृग्गतिः कुवशात् ।
क्षितिजे स्व दृक् छाया भूव्यासार्धं नभोमध्यात् ॥ —*Arya.* IV. 33-34

2. loc. cit. *MBh.* V. 24-27

3. loc. cit. *BrSpSi.* XI. 23-25

(viii) Moon's true latitude=Moon's latitude × *nati*.

The present Sūryasiddhānta and Brahmagupta both utilise the following expressions for *lambana* and *nati* which give more accurate values:

$$lambana = \frac{\text{Rsin}\,(M - \odot) \times d\d{r}ggati\text{'}y\bar{a}}{\{\text{Rsin}\,(30^\circ)\}^2} \text{ ghaṭis}$$

where M and ☉ denote the longitudes of the meridian ecliptic and the Sun respectively.

$$nati = \frac{d\d{r}kk\d{s}epajy\bar{a} \times d}{15 \times R}$$

where R is the radius of the celestial sphere and d denotes the difference between the daily motions of the Sun and the Moon[1].

Brahmagupta has raised objections to the Āryabhaṭa system regarding *lambana* (XI. 26-28), *dṛkkṣepa* (XI. 30-31) *ayanadṛk-karma* (XI. 35), elevation of Moon's horns (*śṛṅgonnati*) (XI. 39) and similar several other points. He is so vehemently opposed to Āryabhaṭa that finally he declares:

> "It is beyond my capacity to enumerate all the defects of Āryabhaṭa. Only a few have been given here as illustration. Intelligent people can easily find out others[2].

He also says:

> Āryabhaṭa is neither conversant with the Gaṇita (mathematics), nor Kāla (time calculations) nor Gola (celestial or spherical calculations). It is difficult to enumerate separately the fallacies committed by him in the respective chapters of the *Gaṇitapāda*, *Kālakriyāpāda* and *Golapāda*[3].

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1. loc. cit. *BrSpSi*. XI. 23.
2. आर्यभटदूषणानां संख्या वक्तुं न शक्यते यस्मात् ।
   तस्मादयमुद्देशो बुद्धिमताऽन्यानि योज्यानि ॥ —*BrSpSi*. XI. 44
3. जानात्येकमपि यतो नार्यभटो गणितकालगोलानाम् ।
   न मया प्रोक्तानि ततः पृथक् पृथग् दूषणान्येषाम् ॥ —*BrSpSi*. XI. 43.

Brahmagupta and Śrīṣeṇa

In Varāhamihira's *Pañcasiddhāntikā* we have a critical review of the five *Siddhāntas* or five systems of astronomical study : Puliśa Siddhānta, Romaka Siddhānta, Vasiṣṭha Siddhānta, Sūrya Siddhānta and Brāhma Siddhānta. Colebrooke in his Paper "*On the notion of the Hindu Astronomers concerning the precession of the equinoxes and motions of the planets*", published in the *Asiatic Researches*, vol. xii. p. 209-250, Calcutta. 1816,4 to, reproduced in the *Miscellaneous Essays*. Vol. II. 1872, says the following in regards to the authorship of these schools of astronomy :

> All these books are frequently cited in the astronomical compilations and are occasionally referred to their real or supposed authors. The first is everywhere assigned to Puliśa, whose name it bears. The *Romaka Siddhānta* is ascribed by the scholiast of Brahmagupta and by a commentator of the *Sūrya Siddhānta* to Śrīṣeṇa. The Vāsiṣṭha Siddhānta is by the same authority given to Viṣṇucandra. Both these authors are repeatedly mentioned with censure by Brahmagupta ; and it is acknowledged that they are entitled to no particular deference.
>
> The *Brāhmṇa Siddhānta*, which is the basis of Brahmagupta's work, is not anywhere attributed to a known author ; but referred to in all quotations of it which have fallen under observation, either to the *Viṣṇudharmottara Purāṇa*, of which it is considered as forming a part, or to Brahmā (also called Pitāmaha) who is introduced into it as the speaker in a dialogue with Bhṛgu, or it is acknowledged to be the work of some unknown person. The true author it may be now impracticable to discover, and would be vain to conjecture.
>
> The *Sūrya Siddhānta* (if the same which we now possess) is in the like manner ascribed to no certain author unless in the passage cited by my colleague Mr. Bently (*Asiatic Researches*, vol. vi. p. 572) who says that "in the commentary of the *Bhāsvatī*, it is declared, that

> Varāha was the author of the *Sūrya Siddhānata*", and who adds, that "Satānanda, the author of the *Bhāsvatī* was a pupil of Varāha under whose directions, he himself acknowledges, he wrote that work".
>
> This concluding remark alludes to the following verse of the *Bhāsvatī Karaṇa* : "Next I will propound succinctly., from Mihira's instruction, (the system) equal to the *Sūrya Siddhānta*[1], (*Miscellaneous Essays*, p. 388-90) (The word 'Mihira' has double meaning : it might be an abbreviation of *Varāhamihira*, or it may mean sun or *Sūrya*).

Thus on the authority of Colebrooke, Srīṣeṇa may by regarded as the initiator of the Romaka system. Brahmagupta himself mentions in one of his passages the name of Srīṣeṇa in connection with the Romaka system, and further the conceptions of the Romaka system came down as Vāsiṣṭha system through Viṣṇucandra,[2] Lāṭadeva also derived from Srīṣeṇa the concepts of the mean motions of the Sun, the Moon, the Moon's apogee and her node and the mean motions of Mars. Mercury's. *Śighra*, Jupiter, Venus' *śigrha* and Saturn. I have indicated elsewhere, which is also the view of Sankara Bālakṛṣṇa Dīkṣita, that the original Romaka and Pauliśa Siddhāntas were introduced to Indians by Lāṭadeva, and the latter Romaka Siddhānta by Srīṣeṇa (Original Romaka Siddhānta was prevalent before Śaka 427 and this is the one which is mentioned by Varāhamihira who makes no reference to Srīṣena and Viṣṇucandra in the *Pañcasidhāntikā*, and the latter Romaka Siddhānta was introduced by Śrīṣeṇa as is indicated by Brahmagupta. Thus we have two Vāsiṣṭha Siddhāntas and two Romaka Siddhāntas). My personal view is that Lāṭadeva, Śrīṣeṇa and possibly Viṣṇucandra also, were naturalised Greeks, settled in India and they had adopted themselve to Indian life. They were conversant in Greek and Indian Astronomy both and had contributed substantially to Indian astronomy. Brahmagupta was opposed to any of these f oreign influences dominating Indian

1. अथ प्रवक्ष्ये मिहिरोपदेशात् तत्सूर्यसिद्धान्त समं समासात् ॥

—*Bhāsvatī Karaṇa*

2. श्रीषेणेन गृहीत्वा रत्नोच्चयरोमकः कृतः कन्था ।
एतानेव गृहीत्वा वासिष्ठो विष्णुचन्द्रेण ॥ —*BrSpSi*. XI. 50

systems, and he very much resented such interferences in pure academic life of this country. He was opposed to Āryabhaṭa for a different reason. Āryabhaṭa was universally regarded as an authority in this country, and the conservativism was so deep that even where it could be shown by direct observation or on valid theoretical grounds, that a particular concept was erroneous or less accurate, people still chose to adhere to it, since they had the backing of Āryabhaṭa's authority. Brahmagupta was against this nonscientific attitude. Needless to say, Brahmagupta was not always fair to Āryabhaṭa in his criticism ; he overdid in enumerating the shortcomings of Āryabhaṭa's system, as if he was personally jealous of his wide popularity.

Brahmagupta's feelings against Lāṭadeva, Śrīṣeṇa, Viṣṇucandra and others would be seen from the following passage in the *Brāhmasphuṭasiddhānta* :

> From the fact that Śrīṣeṇa, Viṣṇucandra, Pradyumna Āryabhaṭa, Lāṭa, and Siṁha contradict one another regarding eclipses and similar topics, their ignorance, is proved daily. The criticisms which I have passed on Āryabhaṭa are, with the requisite modifications, to be applied to the doctrines of each of these teachers as well. I will, however, make some further critical remarks on Śrīṣeṇa and others.
>
> Srīṣeṇa took from Lāṭa the rules concerning the mean motions of the Sun, and the Moon, the Moon's apogee and her node, and the mean motions of Mars, Mercury's Śīghra, Jupiter, Venus's Śīghra, and Saturn ; he took elapsed years and the revolutions of *yuga* (*yuga-yāta-varṣa-bhagaṇa*) from Vasiṣṭha and the *Pādakaraṇa* of Vijayānandi; further took from Āryabhaṭa the rules concerning the apogee, epicycycles and nodes, and those referring to the true motions of the planets and thus the Romaka Siddhānta which was (or is) a heap of jewels (as it were) has, by Śrīṣeṇa, been made into a patched rag (as it were)[1].

1. श्रीषेणविष्णुचन्द्र प्रद्युम्नार्यभटलाटसिंहानाम् ।
ग्रहणादिविसंवादात् प्रतिदिवसं द्विगुणमज्ञत्वम् ॥

[*Cont. on Page 330*]

Brahmagupta very emphatically says about his system that so long as people would be finding concordance between the observed and theoretical results *(dṛggaṇitaikyam)* in respect of solar and lunar eclipses, his Brāhma Siddhānta would be held in esteem[1].

In other systems, whatever concordance appears to be between the observation and calculation, of eclipses etc., it is, Brahmagupta says, merely accidental or by chance, as the maxim of letters bored by an insect in wood or paper[2].

[*Cont. from Page 329*]

युक्तयाऽऽर्यभटोक्तानि प्रत्येकं दूषणानि योज्यानि ।
श्रीषेणप्रभृतीनां कानि चिदन्यानि वक्ष्यामि ॥

लाटात् सूर्यशशांकौ मध्याबिन्दूच्च चन्द्रपातौ च ।
कुजबुधशीघ्रबृहस्पति सितशीघ्र शनैश्चरान् मध्यान् ॥

युगयातवर्षभगणान् वासिष्ठाद्विजयनन्दि कृतपादात् ।
मन्दोच्च परिधिपातस्पष्टीकरणाद्यमार्यभटात् ॥

श्रीषेणेन गृहीत्वा रत्नोच्चयरोमकः कृतः कन्था ।
एतानेव गृहीत्वा वासिष्ठो विष्णुचन्द्रेण ॥ —*BrSpSi*. XII. 46-50

2. चन्द्ररवि ग्रहणेन्दुच्छायादिषु सर्वदा यतो ब्राह्मे ।
दृग्गणितैक्यं भवति स्फुटसिद्धान्तस्ततो ब्राह्मः ॥ —*BrSpSi*. XI. 61

3. अनयोर्न कदाचिदपि ग्रहणादिषु भवति दृष्टिगणितैक्यम् ।
यद्भवति तद् घुणाक्षरमतोऽस्फुटाभ्यां किमेताभ्याम् ॥ —*BrSpSi*. XI. 51.

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CHAPTER XIII

Brahmagupta and Astronomical Instruments

The Twenty-second Chapter of the *Brāhmasphuṭasiddhānta* is known as the *Yantrādhyāya* or a chapter on instruments. There is a description of seventeen types of time-reckoning instruments (*Kāla-yantra*)[1] :

1. Dhanuryantra—Bow instrument.
2. Turyagolaka yantra—Quadrant (one-fourth sphere)
3. Cakra yantra=wheel or circle.
4. Yaṣṭi yantra—a pole or staff instrument.
5. Śaṅku yantra—Gnomon.
6. Ghaṭikā yantra—a clock or pot instrument.
7. Kapāla yantra—Bowl or potsherd instrument.
8. Karttarī yantra—Scissor or knife ; cutter.
9. Pīṭha yantra=Pedastal or seat instrument.
10. Salila yantra—Water-leveller.
11. Brahma or Śāṇa yantra—For describing circles.
12. Avalamba Sūtra—Threads with plumbs (Plumb lines).
13. Karṇa or chāyā-karṇa—A set of squares for diagonals.
14. Chāyā or śaṅku-chāyā—Sundial.

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1. सप्तदश कालयन्त्राण्यतो धनुस्तुर्यगोलकं चक्रम् ।
यष्टिः शंकुर्घटिका कपालकं कर्त्तरी पीठम् ॥
सलिलं भ्रमोऽवलम्बः कर्णश्छाया दिनार्धमर्कोऽक्षः ।
नतकालज्ञानार्थं तेषां संसाधनान्यष्टौ ॥ —*BrSpSi. XXIII*, 5-6

15. Dinārdha yantra—Midday measure instrument.
16. Arka yantra—Sun-instrument.
17. Akṣa or Palāṅśa yantra—Small degree measure arc instrument.

Salila yantra is used for levelling; since a liquid such as water seeks its own level, it can be utilised to know whether a surface has been levelled or not.[1] Bhrama or *Śāṇa* is used for drawing circles. Avalambaka or plambline is used for adjusting vertical line. *Karṇa* is used in connection with angles and diagonals. From S*alila* (no. 10) to the last (no. 17); these eight are used for adjustments and are basically important.

The *dhanuryantra* is used for *nata* and *unnata* kāla *ghaṭikās*.

On the *paridhi* or the circumference of the *cakra-yantra* are indicated the twelve *rāśis*. ending up to Mīna (XXII. 18). Brahmagupta has described the *yaṣṭi yantra* and shown how it could be used to give time at different parts of the day, and from its shadow *dṛgjyā* and other characteristics can be calculated. This instrument can also be used for ascertaining the solar-lunar differences, and for fixing up the directions. It can be used for determining various heights and altitudes.

The *karttarī yantra* is of the shape of a pair of scissors with two semi-circular blades, fastended to a string at the centre; at the centre is fixed a pin or a pole which casts shadows.

Setting up of the Gnomon

Here it would be interesting to describe the setting of a gnomon, which K.S. Shukla has given in details while commenting on the *Mahābhāskarīya* (IV. 1):

> After having tested the level of the ground by means of water, draw a neat circle with a pair of compasses (*karkaṭa*) (At the centre of that circle, set up a vertical gnomon). The gnomon should be large, cylindrical, massive, and tested for its perpendicularity by means of four threads with plumbs (*avalmbaka*) tied to them.

1. सलिलेन समं साध्यं भ्रमेण वृत्तमवलम्बकेनोर्ध्वम् ।
तिर्यक् कर्णोनान्यैः कथितैश्च नव प्रवक्ष्यामि ॥ —*BrSpSi* XXII. 7.

Bhāskara I in his commentary on the *Āryabhaṭīya* tells us that there was a difference of opinion amongst astronomers in his time regarding the shape and size of gnomon (also called style). Some astronomers prescribed a gnomon with its one-third in the bottom of the shape of a prism on a square base (*caturasra*), one-third in the middle of the shape of a cow's tail (*go-pucchākāra*). and one-third at the top of the shape of a spear-head (*Śūlākāra*) and some others prescribed a square prismoidal (*samacaturasra*), gnomon. The followers of Āryabhaṭa I, he informs us, prescribed the use of a broad (*pṛthu*), massive (*guru*), and large (*dīrgha* cylindrical gnomon, made of excellent timber and free from any hole, a scar or knot on its body. In the above stanza, Bhāskara I prescribes this last kind of gnomon : the other two kinds he proves in the commentary to be defective and so he rejects them.

For getting the shadow-end easily and correctly the cylindrical gnomon was surmounted by a fine cylindrical iron or wooden nail fixed vertically at the centre of the upper end. The nail was taken to be longer than the radius of the gnomon, so that its shadow was always seen on the ground.

Certain writers, Bhāskara I tells us in the commentary, prescribed a gnomon of half a cubit (=12 *aṅgulas*) in length and having twelve divisions. But according to Bhāskara I (although it was the usual custom) there was no such hard and fast rule. The gnomon could be of any length and any number of divisions. The gnomon should, however, be large enough, so that the rings of graduation on the gnomon may be clearly seen on the shadow. A broad and massive gnomon was preferred because it was unaffected by the wind.

Brahmagupta describes gnomon which at the bottom is two *aṅgulas* wide, pointed as a needle., 12 *aṅgulas* in length, and full of holes from the basic circular part to the pointed extremity. (*BrSpSi*. XXII. 39).

As regards testing the level of the ground, Bhāskara I observes :

> When there is no wind, place a jar (full) of water upon a tripod on the ground which has been made plane by means of eye or thread, and bore a (fine) hole (at the bottom of the jar) so that the water may

> have continuous flow. Where the water falling on the ground spreads in a circle, there the ground is in perfect level ; where the water accumulates after departing from the circle of water, it is low ; and where the water does not reach, there it is high. (Bhāskara's Commentary on the *Āryabhaṭīya*, II. 13).

After the ground was levelled, a prominently distinct circle was drawn on the ground as stated in the text (*MBh.* III. 1). In the time of Sankaranārāyaṇa (869 A.D.), there it seems that all lines were drawn on the ground with sandal paste (candanākṣodārdra). The above circle having been thus drawn and coated with sandal paste, another small concentric circle was drawn with the radius of the gnomon. The gnomon was then placed vertically with the periphery of its base in coincidence with that circle. The gnomon was thus set up exactly in the middle of the bigger circle. The verticality of the gnomon was tested by means of four plumb lines hung on the four sides of the gnomon

Gnomon Used for Finding the Directions

The rule in this connection has been described by Brahmagupta in *BrSpSi.* III. 1. The same rule in other words has been described by Bhāskara I in *MBh.* III. 2. In the *Vāsanā Bhāṣya*, Pṛthūdaka Svāmī describes the details of determining the directions. The level of the ground is ascertained by means of water and a gnomon of 12 aṅgulas is set up. Find out two points where the shadow of the gnomon enters into and passes out of the circle. Bhāskara prescribes drawing out a fish figure with these points. The thread line which goes through the mouth and tail of the fish figure indicates the north and south directions with respect to the gnomon. Brahmagupta says that if the Sun is on the eastern side, then where the shadow-point enters circle (in the forenoon) that point would be the west, and the point where it emerges out (in the afternoon) is the east.

As the Sun moves along the ecliptic, its declination changes. By the the time the shadow moves between the forenoon and afternoon points as given above, the Sun traverses some distance of the ecliptic and, so, theoretically speaking, its

declination gets changed. It follows, therefore, that the East-West line in the above determination is not the true position of the actual East-West line. *Brahmagupta* (628 A. D.) *was the first Hindu astronomer who prescribed the determination of the East-West line with proper allowance for the change in the Sun's declination.* (Shukla) The details of the method intended by him have been supplied by his commentator Pṛthūdaka Svāmī (860 A. D.).

Bhāskara and Brahmagupta both give another method of determining directions : (*BrSpSi.* III. 2 ; *MBh.* III. 3) : With the three points (at the ends of the three shadows of the gnomon) corresponding to (any three) different times (in the day), draw two fish-figures (each with two of the three points) in accordance with the usual method. From the point of intersection of the lines passing through the mouth and tail (of the two fish-figures), determine the north and south directions. (*MBh.* III. 3).

Brahmagupta in his rule is more precise :

> The point where the lines passing through the two fish-figures, which are drawn by means of three shadow ends (of the gnomon), intersect each other is for places in the northern hemisphere, the south direction, (if the midday shadow falls to the north of the foot of the gnomon). If the midday shadow falls towards the south of the foot of the gnomon, it is the north direction. (*BrSpSi.* III. 2).

This rule is obviously based on the assumption that the the locus of the end of the shadow of the gnomon is a circle. In fact the locus for places whose latitude is less than (90°—the obliquity of the ecliptic), this locus is a hyperbola.

Brahmagupta has made numerous uses of gnomon. He and Bhāskara, for example, both give the rules for finding the latitude and colatiude and the zenith distance and altitude of the Sun by finding out the length of the shadow and the length of the gnomon (*BrSpSi.* III. 10 ; *MBh.* III. 5) ; also rule for the determination of the latitude with the help of the Sun's meridian zenith distance and declination (*BrSpSi.* III. 13 ; *MBh.*

III. 17) ; also rule for finding the Sun's altitude (*BrSpSi*. III. 27 ; *MBh*. III. 24) (The Sun's altitude for the night has been called by Brahmagupta as *pātāla-śaṅku*, *BrSpSi*. XV. 9).

Golayantra or Armillary Sphere

The first mention of the Golayantra or the armillary sphere is in the *Aryabhaṭīya* (Golapāda. 22)[1] which was a uniformly round circle made of wood or of bamboo and which was ot uniform weight or density alround. It was levelled with mercury, oil or water. A śalākā or pin (or rod) was fixed in it in the south-north direction. Its description from the commentary *Bhaṭadīpikā* of Paramādīśvara is given here :

> A sphere of wood. uniformly round on all sides and with uniform density, and also light is made to revolve round an iron axis fixed north-south without friction (oil may be introduced to avoid friction). To the backside of the sphere, is fixed a *nālaka* full of water which has the length equal to the circumference of the sphere: and which has a hole at the bottom.
>
> Now a thread, connected to the hook of the wooden ball (on the top side) passing over another small ball (in the same axis of the wooden ball) is attached to the mercury lobe by its other end. The mercury lobe is placed on the level of water and water is allowed to flow through the bottom hole and with water mercury lobe also goes down. The time in which the above hook of ball comes to bottom (180°) is noted. The experiment is repeated with oil. The use of this mechanism is to revolve the ball by water or oil[1]

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1. काष्ठमयं समवृत्तं समन्ततस्सम गुरु लघुं गोलम् ।
पारतं तैलजलैस्तं भ्रमयेत्स्वधिया च कालसमम् ॥ *Arya. IV. 22*

काष्ठमयं वंशादि काष्ठेन निर्मितं समवृत्तं सर्वतोवृत्तं समन्ततस्सम गुरुं सर्वावयवेषु समं गुरुत्वं यथा भवति तथा कृतं । लघुमगुरं एवं भूतं गोलं कृत्वा पारतादिभिस्तं स्वधिया च कालसमं भ्रमयेत् । अयमर्थः । भूमिष्ठ दक्षिणोत्तरस्तम्भयोरुपरि गोलप्रोतायश्शलाकाया अग्रे स्थापयेत् । गोलदक्षिणोत्तराच्छिद्रे च तैलेन सिञ्चेत् यथा निस्संङ्गो गोलो भ्रमति । गोलस्यापरतो गोलपरिधिसंमित दैर्घ्यं साधश्छिद्रं जलपूर्णं नलकं निदध्यात् ततो गोलस्यापरस्वस्तिक कीलकं निधाय तस्मिन्सूत्रस्यैक मग्रं बद्ध्वादो विषुवन्मण्डलपृष्ठेन प्राङ्मुखं नीत्वा तदग्रबद्धं पारतपूर्णमलाबु जलपूर्णे नलके निदध्यात् ततो नलकस्याध

[*Cont. on Page 337*]

In the Arabic epitome of the Almagest entitled *Tahriru'l mejesti*. the armillary sphere, *Za ul halk*, is thus described :

> Two equal circles are placed at right angles, the one representing the ecliptic, the other the solstitial colure. Two pins pass throught the poles of the ecliptic and two other pins are placed on the poles of the equator. On the first two pins are suspended a couple of circles moving, the one within, the other without, the first mentioned circles, and representing two secondaries of the ecliptic. On the two other pins a circle is placed, which encompasses the whole instrument, and within which the different circles turn; it represents the meridian. Within the inner secondary of the ecliptic, a circle is fitted to it, in the same plane and turning in it. This is adapted to measure latitudes. To this internal circle, two apertures or sights, opposite to each other, and without its plane are adapted like the sights of an instrument for altitudes. The armillary sphere is complete when consisting of these six circles. The ecliptic and secondaries are to be graduated as minutely as may be practicable. It is best to place both secondaries, as by some directed, within the ecliptic (instead of placing one of them without it), that the complete revolution of the outer secondary may not be obstructed by the pins at the poles of the equator. The meridian likewise should be doubled, or made to consist of two circles; the external one graduated and the internal one moving within it. Thus the pole may be adjusted at its proper elevation above the horizon of any place. The instrument so constructed consists of seven circles.
>
> It is remarked that when the circle representing the meridian, is placed in the plane of the true meridian, so

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च्छिद्रं विकृतं कुर्यात् तेन जलं निस्स्रवति। नलकस्य जलमधो गच्छति। तद्वशाच्च तन्नस्थमलाबु पारतपूर्त्यां गुरुत्वज्जलेन सहाधो गच्छद गोलं प्रत्यङ्मुखमाकर्षति। एवं त्रिंशद् घटिकाभिरर्धसंमितं यथा जलं भवति गोलस्य चार्धं भ्रमति तथा स्वबुद्ध्या जलनिस्रावो योज्यः। इति।

> अमृतस्रावयोगेन कालभ्रमण साधनम्।
> गुणबीजसमाकृष्टं गोलयंत्रं प्रकल्पयेत्॥
>
> *SuSi. XIII, 16-17*

that it cuts the plane of the horizon at right angles, and one of the poles of the equator is elevated above the horizon conformably with the latitude of the place; then the motions of all the circles round the poles represent the motions of the universe.

After rectifying the meridian, if it be wished to observe the Sun and Moon together, the outer secondary of the ecliptic must be made to intersect the ecliptic at the Sun's place for that time: and the solstitial colure must be moved until the place of intersection be opposite to the Sun. Both circles are thus adjusted to their true places; or if any object but the Sun, be observed, the colure is turned until the object be seen in its proper place, on that secondary referred to the ecliptic: the circle representing the ecliptic being at the same time in the plane of the true ecliptic and in its proper situation. Afterwards, the inner secondary is turned towards the Moon (or to any star intended to be observed), and the smaller circle within it, bearing the two sights is turned, until the Moon, (or to any star intended to be observed), and the smaller circle within it, bearing the two sights, is turned, until the Moon be seen in the line of the apertures. The intersection of the secondary circle and ecliptic is the place of the Moon in longitude: and the arc of the secondary, between the aperture and the ecliptic, is the latitude of the Moon on either side (North or South). (From Colebrooke's *Miscellaneous Essays*).

The same instrument, as described by Montucla from the text of Ptolemy (1. 3. c. 2) consists of six circles: first a large circle representing the meridian; next four circles united together, representing the equator, ecliptic and two colures, and turning within the first circle on the poles of the equator, lastly a circle turning on the poles of the ecliptic, furnished with sights and nearly touching, on its concave side, the circumference of the ecliptic.

The armillary sphere described by the Arabian epitomiser, differs, therefore; from Ptolemy's in omitting the equator and

equinoctial colure, and adding an inner secondary of the ecliptic, which as well as the meridian, is doubled.

According to Lalande, the astrolobe of Ptolemy, from which Tycho Brahe derived his equatorial armillary, consisted only of four circles: two placed at right angles to represent the ecliptic and solstitial colure; a third turning on the poles of the ecliptic and serving to mark longitudes; and a fourth, within the other three, furnished with sights to observe celestial objects and measure their latitudes and longitudes.

Whether the ancient Greeks had any more complicated instrument formed on similar principles, and applicable to astronomical observations, is perhaps uncertain. We have no detailed description of the instrument which Archimedes is said to have devised to represent the phenomena and motions of the heavenly bodies; nor any sufficient hint of its construction; nor does Cicero's account of the sphere exhibited by Posidonius suggest a distinct notion of its structure.

Among the Arabs, no addition is at present known to have been made to the armillary sphere; between the period when the Almagest was translated and the time of Alhazen, who wrote a treatise of optics, in which a more complicated instrument than that of Ptolemy, is described; Alhazen's armillary sphere is stated to have been the prototype of Tycho Brahe's; but neither the original treatise, nor the Latin translation of it, are procurable and one is therefore unable to ascertain whether the sphere, mentioned by the Arabian author, resembled that described by Indian astronomers. At all events, says Colebrooke, he is more modern than the oldest of the Hindu writers.

Here we give the literal translation of the passage on armillary sphere or *Golayantra* occurring in the *Sūrya-Siddhānta* :

> Let the astronomer frame the surprising structure of the terrestitial and celestial spheres.
>
> Having caused a wooden globe to be made (of such size) as he pleases; to represent the Earth : with a staff for the axis passing through the centre, and exceeding the globe at both ends; let him place the supporting hooks, as also the equinoctial circle.
>
> Three circles must be prepared, (divided for signs and degrees), the radius of which must agree with the

respective diurnal circles, in proportion to the equinoctial: the three circles should be placed for the Ram (*Meṣa*) and following signs. respectively, at the proper declination in degrees N. or S. ; the same answer contrariwise for the Crab (*Karkaṭa*) and other signs. In like manner three circles are placed in the southern hemisphere, for the Balance (*Tulā*) and the rest, and contrariwise for Capricorn (*Mṛga*) and remaining signs. Circles are similarly placed on both hoops for the asterisms in both hemispheres, as also for *Abhijit* and for the *Seven Ṛṣis*, *Agastya*, *Brahmahṛdaya* and other stars.

In the middle of all these circles is placed the equinoctial. At the intersection of that and supporting hoops, the distant from each other half the signs, the two equinoxes should be determined; and the two solstices, at the degrees of obliquity from the equinoctial; and the the places of the Ram (*Meṣa*) and the rest, in the order of the signs, should be adjusted by the strings of the curve. Another circle thus passing from equinox to equinox, is named the ecliptic; and by this path, the Sun illuminating worlds, for ever travels. The Moon and other planets are seen deviating from their nodes in the ecliptic to the extent of their respective greatest latitudes (within the zodiac).[1]

1. भूलोकस्य रचनां कुर्यादाश्चर्यकारिणीम् ।
अभीष्टं पृथिवीगोलं कारयित्वा तु दारवम् ॥
दण्डं तन्मध्यगं मेरोरुभयत्र विनिर्गतम् ।
आधारकक्ष्याद्वितयं कक्ष्यां वैषुवतीं तथा ॥
भगणांशुलैः कार्या दलितास्तिस्र एव ताः ।
स्वाहोरात्रार्धकर्णैश्च तत्प्रमाणानुपाततः ॥
क्रान्तिविक्षेपभागैश्च दलिता दक्षिणोत्तरा ।
स्वैस्स्वरपक्रमैः कार्या मेषादं नामपक्रमात् ॥
कक्ष्याः प्रकल्पयेत्ताश्च कर्क्यादीनां विपर्ययात् ।
तद्वत्तिस्रस्तुलादीनां मृगादीनां विलोमतः ॥
याम्यगोलाश्रिताः कुर्यात् कक्ष्याधारद्वयोपरि ।
याम्योदग्भाग संस्थानां भानामभिजितस्तथा ॥
सप्तर्षीणामगस्त्यस्य ब्रह्मादीनां प्रकल्पयेत् ।
मध्ये वैषुवती कक्ष्या सर्वासामेव संस्थिता ।

[Cont. on page 341]

The author of the *Sūrya-Siddhānta* then proceeds to notice the relation of the great circles before mentioned to the horizon, and observes that whatever place be assumed for the apex of the sphere, the middle of the heaven for that place is its horizon. He concludes by showing, that the instrument may be made to revolve with regularity, by means of a current of water; and hints, that the appearance of spontaneous motion may be given, by a concealed mechanism, for which quicksilver is to be employed. There is a hint of secrecy also in one of the lines, and it has, therefore, been stated that the construction and the mechanism of working should be learnt under the guidance of a teacher.

How to Observe Places of Stars

Details are not available in this connection. The *Sūrya-Siddhānta* only hints "that the astronomer should frame a sphere and examine the apparent longitude and latitude (*sphutavik ṣepa and sphuṭadhruvaka*)". The commentators, however, describe the manner of making the observation. They direct a spherical instrument (*Golayantra*) to be constructed as described above. This instrument is very much similar to the armillary sphere. An additional circle graduated for degrees and minutes, is directed to be suspended on the pins of the axis as pivots. It is named as *Vedhavalaya* or intersecting circle, and appears to be a circle of declination. After noticing this addition to the instrument, the instructions proceed to the rectifying of the *Golayanṭra* or armillary sphere which is said to be placed, so that the axis shall point to the pole: and the horizon be true by a water level.

The instrument being thus placed, the observer is instructed to look at the star *Revatī* through a sight fitted to an orifice at the centre of the sphere; and having found the star, to adjust by it the end of the sign Pisces on the ecliptic. The observer is then to look through the sight, at the *yoga* star of *Aśvinī*, or at

तदाधारयुतेः भार्धमयने विषुवद्वये ।
अयनादयने चैव कक्ष्या तिर्यक्तथाऽपरा ॥

क्रान्तिसंज्ञा तया सूर्यः सदा सदापर्येति भासयन् ।
चन्द्राद्याश्च स्वकैः पातैपमण्डलमाश्रितैः ॥

ततोऽपकृष्टादृश्यन्ते विक्षेपाग्रेष्वपक्रमात् । *SuSi. XIII. 3-12*

some other proposed object; and to bring the moveable circle of declination over it. The distance in degrees, from the intersection of this circle and ecliptic, to the end of *Mīna* or Pisces, is its longitude (*dhruvaka*) in degrees; and the number of degrees on the moveable circle of declination, from the same intersection to the place of the star, is its latitude (*vikṣepa*) North or South.

The commentators have rightly remarked that the "latitude so found is *sphuṭa* or apparent, being the place intercepted between the star and the ecliptic, on a circle passing through the poles; but the true latitude (*asphuṭa*) is found on a circle hung upon the poles of the celestial sphere as directed in another place". (From Colebrooke's Paper on the Indian and Arabian Divisions of the Zodiac. *Miscellaneous Essays*, Vol. II, 324-326).

For the details of the *Golayantra*, readers are requested to refer to the description in the *Siddhānta-Śiromaṇi* of Bhāskara II.

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Reference

Brahmagupta : yantrādhyāya in —*BrSpSi*.
K.S. Shukla : The *Mahābhāskarīya*.
Bhāskara I : Commentary on the *Āryabhaṭīya*.
Paramādīśvara : *Bhaṭadīpikā*, a commentary on the *Āryabhaṭīya*,
H.T. Colebrooke : *Miscellaneous Essays*, Vol. II., 1872.

॥ श्रीगणेशायनमः ॥[1]

अथ ब्राह्मस्फुट सिद्धान्तस्य

पूर्वादशाध्याय्यां मध्यमाधिकारः

जयति प्रणतसुरासुरकिरीटरत्नप्रभाच्छुरितपादः ।
कर्ता जगदुत्पत्तिस्थितिविलयानां महादेवः ॥१॥

ब्रह्मणोक्तं ग्रहगणितं महता कालेन यत् खिलीभूतम् ।
अभिधीयते स्फुटं तज्जिष्णुसुतब्रह्मगुप्तेन ॥ २ ॥

ध्रुवताराप्रतिबद्धं ज्योतिश्चक्रं प्रतिक्षणगमादौ ।
पौष्णाश्विन्यन्तस्थैः[1] सह ग्रहैर्ब्रह्मणा सृष्टम् ॥ ३ ॥

चैत्र[4]सितादेरुदयाद्भानोर्दि[1]नमासवर्ष युगकल्पाः ।
सृष्ट्यादौ लंकायां सम[3]ं प्रवृत्ता दिनेऽर्कस्य[2] ॥ ४ ॥

प्राणैर्विनाडिकार्क्षी षड्भिर्घटिका विनाडिका षष्ट्या ।
घटिका षष्ट्या दिवसो दिवसानां त्रिंशता मासाः ॥ ५ ॥

(ग) १. श्री नमः ॥ परमात्मने । श्री रामाय सीतालक्ष्मणसहिताय: ॥ श्री गुरुभ्यो नमः ॥ for (श्री..........मध्यमाधिकारः)

(च) १. "ॐ नमः परमात्मने श्रीरामाय सीतालक्ष्मणसहिताय श्री गुरुभ्यो नमः । for (श्री.........मध्यमाधिकारः)"

३. (ग) १. पौष्णाश्विनांतरस्थैः for (पौष्णाश्विन्यन्तस्थैः)
(च) १. पौष्णाश्विन्यंतरास्थैः for (पौष्णाश्विन्यन्तस्थैः)

४. (ग) १. र्द्दिन (च) for (र्दिन)
२. ऽर्क्कस्य for (ऽर्कस्य) (ख) दिनेर्कस्य for (दिनेऽर्कस्य)
(क) श्लोक उपलब्ध नहीं
(ख) ३. समप्रवृत्ता for (समं प्रवृत्ता)
(च) ४. चित्र for (चैत्र) २. दिनेऽर्क्कस्य for (दिनेऽर्कस्य)

५. (क) श्लोक उपलब्ध नहीं ।

मासा[1] द्वादशवर्षं विकलालिप्तांशराशिभगणांतः[2]
क्षेत्रविभागस्तुल्यः कालेन विनाडिकाद्येन[3] ॥ ६ ॥
स्वचतुष्टयरदवेदा[1] रविवर्षाणां चतुर्युगं[2] भवति । ४३२००००
सन्ध्या सन्ध्यांशै[3] सह चत्वारि पृथवकृतादीनि ॥७॥
युगदशभागो[1] गुणितः कृतं चतुर्भिस्त्रि[2]भिर्गुणस्त्रेता[3] ।
द्विगुणो[4] द्वापरमेकेन संगुणः कलियुगं भवति ॥ ८ ॥
१७२८०००।१२९६०००।८३४०००[5]।४३२०००
युगपादानार्यभट[1]श्चत्वारि समानि[2] कृतयुगादीनि[3] । १००००००
यदभिहितवान्[4] न तेषां स्मृत्युक्तसमानमेकमपि[5] ॥ ९ ॥

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६. (ख) १. मास for (मासा)
२. भगणांत for (भगणांतः)
३. द्येवम् for (द्येन)

(च) २. भगणांताः for (भगणांतः)

७. (ग) १. खचतुष्टय for (स्वचतुष्टय) (क) (ख) (च)
(क) २, संख्या लुप्त है। टीका में उपलब्ध है।
(ख) ३. संध्यांशैः for (सन्ध्यांशै)

८. (ग) १+१०+(च)
२+४+(च)
३+३+(क) गुणोत्रेता for (गुणस्त्रेता) (च) +३+
४+२+(च)
५ ८६४००० for (८३४०००) (क) टीका में उपलब्ध है। (च) ८६४०००

(क) संख्याएं लुप्त हैं, परन्तु टीका में दी हुई हैं। (ख)

९. (घ) १. नार्यः for (नार्य) (क) नार्यभट्ट for (नार्यभट)
(ग) २. समानिष्ट (ख) सभाति (च) समानिष्ट for (समानि)
(क) ३. संख्या लुप्त है।
४. हतवान्न for (हितवान् न)
५. समानामेकमपि (च) for (समानमेकमपि)

मनुरेक सप्ततियुगः कल्पो मनवश्चतुर्दश मनूनाम् ।
आद्यंतरांतसंधिषु कृतकालोऽस्माद्युगसहस्रम् ।। १० ।।
४३२००००००

आद्यंतरातसंधिषु कल्पमनूनां कृताब्दसमकालम् ।
नेच्छंति ये षड्नं तेषां कल्पो युगसहस्रम् ।। ११ ।।
४२९४०८००००

मनुसंधियुगमिच्छत्यार्यभटस्तन्मनुर्यतस्खयुगः ।
कल्पश्चतुर्युगानां सहस्रमष्टाधिकं तस्य ।।१२।।
४३५४५६००००

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१०. (घ) २. ४३२०००००० for (४३२००००००००) (क) संख्या लुप्त है। टीका में अंकित है।

(ग) २+७१+(च)

३ कल्पो नवचतुर्दश १४ (च) for (कल्पोमनवश्चतुर्दश)

४ +१५+(ख) कृतकल्पो for (कृतकालो) (च)+१५+

(ख) ५. अद्यंतगतसंधिषु for (आद्यंतरांतसंधिषु)

६. स्मुद्युगसहस्रम् for (स्माद्युगसहस्रम्)

११. (घ) १. ड्नं for (षड्नं) (च) षड्नां for (षड्नं)

२. ४२६४०८०००० for (४२९४०८००००) (क) संख्या लुप्त है

(क) ३. युगसहश्र for (युगसहस्रम्)

(ख) ४. अद्यंतरांत for (आद्यंरांत)

५. कल्पमनुना for (कल्पमनूनां)

६. कृताब्दाः for (कृताब्द)

१२. (घ) १. (अस्पष्ट)

२. चतुर्यगाणां for (चतुर्युगानां)

(ग) ३. सहश्रमष्टाधिकं for (सहस्रमष्टाधिकं) (ख)

४. संख्या लुप्त है।

(ख) ५. कृतमिच्छात्यार्य for (युगमिच्छत्यार्य)

६. कल्पाश्चतुर्गुणां for (कल्पश्चतुर्युगानां)

(च) ७. +७२+

युगमन्वन्तरकल्पाः काल[2]परिच्छेदकाः स्मृतावुक्ताः ।
यस्मान्न[1] रोमके ते स्मृति[3] बाह्यो रोमकस्तस्मात् ॥ १३ ॥
काल[1]र्क्षदेशयोगाद्भू[2]यो ग्र[5]हमन्दशीघ्रपातानाम् ।
कल्पेन यतो योगस्तत[3]ः स्फुटं ग्रहयुगं[4] कल्पः ॥ १४ ॥
कल्पेऽर्कबुध[1] सितानां भगणाः[4] शून्यानि सप्तरदवेदाः ।
प्राग्व्रजता[2] कुजगुरुशनिशीघ्रोच्चानां स्वकक्षासु[5] ॥ १५ ॥
[3] ४३२०००००००

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१३. (घ) १. न रोमके ते (च) न रौनुके ते for (न्न रोमके ते)

(ख) २. कलापरिच्छेदकाः for (कालपरिच्छेदकाः)

(च) ३. वि० इस प्रति में "……परिच्छे" के पश्चात् लेखक ने भूल से फिर "मनुरेक सप्तति युग" से लिखना आरंभ कर दिया। इस प्रकार ५⅓ पंक्तियां पुनः लिखी गईं ! उसके पश्चात् फिर क्रमशः लिखता गया ।

४. स्मृतबाह्यो for (स्मृतिबाह्यो)

१४. (घ) १. कालर्क्ष्य (ख) कालक्ष (च) कालक्ष्र्य for (कालर्क्ष)

२. दूद्भूयो (च) for (द्भूयो)

३. तत (च) for (ततः)

४. ग्रहयुगकल्पः (ग) ग्रहयुतं कल्पः for (ग्रहयुगं कल्पः)

(ग) ५. ग्रहशीघ्रमंद पातानां (क) (ख) for (ग्रहमन्द शीघ्रपातानां)

(च) ४. ग्रहयुग कल्पः for (ग्रहयुगं कल्प.)

१५. (घ) १. बुध (च) for (बुध)

२. व्रजनां (ग) व्रजती (ख) व्रजतां for (व्रजता)

(क) २. प्रागव्रजतां for (प्रागव्रजता)

३. संख्या लुप्त है। टीका में अंकित है।

(ख) ४. भगणः for (भगणाः)

५. सा for (सु) (च) ख कक्षासु for (स्व कक्षासु)

पंचांब[3]राणि गुण[४]रामपंच सप्तस्वरेषवः शशिनः ।

[१]५७७५३३०००००

भौमस्य द्वियमशराष्टपक्षवसुरसनव[५]द्वियमाः ॥ १६ ॥

[२]२२९६८२८५२२

[१]९३[४]६९९८९८४

कृतव[१]सुनवाष्टनवनव ष[२]ड्नवागेन्द्वो ज्ञशीघ्रस्य ।

१७९३६९९८९८४[५]

जीवस्य शरेषूदधि षड[3]यक्षि द्विकृतरसरामाः ॥ १७ ॥

३६४२२६४५५[६]

सितशीघ्रस्य यम[१]लगो वेदनवा[६]ष्टाग्नि पक्षयमखनगाः ।

७०२२३८९४९२[४]

अष्टनवप[२]क्षमुनिरसशररसमनवो[3]ऽर्कपुत्रस्य ॥ १८ ॥

१४६५६७२९८[५]

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१६. (क) १. संख्या लुप्त है। टीका में अंकित है।
२. संख्या लुप्त है। टीका में अंकित है।
(ख) ३. पंच वाराणि for (पंचांबराणि)
४. गुणरामं for (गुणराम)
(च) ५. वृद्धि for (वद्वि)

१७. (घ) १. १७९३६९९८९४ for (१७९३६९९८९८४) (च)
२. वांगे (ग) षड्त्रिनव (क) षट्त्रिन (ख) षट्त्रिनवा for (षड्नवागेन्द्वो)
३. पद्यक्ष (ग) षट्द्वयक्षि (क) षट्पक्ष (ख) षष्ट्यक्ष for (षडपक्षि)
(ग) ४. +२२९६८२८५२२ (क) 'ग' में अंकित संख्या १६वें श्लोक की टीका के अन्त में है।
(क) ५. संख्या मूल में नहीं, टीका में अंकित है।
६. संख्या मूल में नहीं, टीका में अंकित है।
(ख) ७. वसू for (वसु)
(च) २. षड्नवांगेदवो for (षड्नवांगेवो) ३ षद्यक्ष for (षडयक्षि)

१८. (घ) १. लागो for (लगो) (च) यमलागो for (यमलगो)
२. यक्ष for (पक्ष)
३. ऽक्कं (ग) ऽक्क for (ऽर्क)
(क) ४. मूल में संख्या लुप्त है। टीका में अंकित है।
५, मूल में संख्या लुप्त है। टीका में अंकित है।
(च) ६. चाष्टाग्नि for (वाष्टाग्नि)

खाष्टाब्धयो[1] ४८० वसुशर[7] वसुपंचखचन्द्रवसुवसुसमुद्राः ।
[8] ४८८१०५८५८

द्विनवयमा[4] २९२ द्वित्रिगुणा[5] ३३२ शरेषुवसव[9] ८५५
स्त्रिपञ्चरसाः[2] । १९ ॥ ६५३[6] ॥ १९ ॥

शशिवेदा ४१ मन्दानामर्कादीनां[1] विलोमपातान्तम्
वसुरसरुद्रेन्द्रगुण द्वित्रियमा[2] २३२३१११६८[3] सप्तरसपक्षाः
[4] २६७ ॥ २० ॥

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१९. (घ) १. षष्ठौदधया (ग) खाष्टोदधयो for (खाष्टाब्धयो)
२. स्त्रिपंचसाः (च) स्त्रिपंचरसाः (स्त्रिपञ्चरसा)
(वि० चिह्नित संख्याएं यहां उपलब्ध नहीं हैं)

(ग) ४. द्विनवयमाः for (द्विनवयमा)
५. द्वित्रिगुणाः for (द्वित्रिगुणा)

(क) १. खाष्टोदधयो for (खाष्टाब्धयो)
६. +शशिवेदाः+
बि० श्लोकांकित कोई भी संख्या मूल में नहीं है। हाँ, टीका में विद्यमान है।

(ख) खाष्टोदधयो for (खाष्टाब्धयो)

(च) १. षाष्टोदधयो for (खाष्टाब्धयो)
७, संख्या लुप्त   ८. संख्या लुप्त   ९. शरेषुवस for (शरेषुवसव)
वि० श्लोकांकित संख्याएं लुप्त हैं।

२०. (घ) यहाँ श्लोक में निर्दिष्ट संख्याएं लुप्त हैं।

(ग) १. मर्क्कादीनां (क) चद्रादीनां (च) for (मर्कादीना)
२. द्वित्रियमाः (क) (ख) द्वित्रियशः for (द्वित्रियमा)

(क) ३. संख्या लुप्त है, परन्तु ठीका में अंकित है। (ख)
४. संख्या लुप्त है, परंतु टीका में अंकित है। (ख)

(च) वि० श्लोकांकित संख्याएं लुप्त हैं।
२ द्वित्रियमाः for (द्वित्रियमा)

शशियमशरा ५२१[4] गुणरसा ६३ स्त्रिनंदवसवः[3]
८९३[4] समुद्रवसुविषयाः ५८४[5] ।
चन्द्रादीनां पश्चात् व्रजतो[1]ऽश्विन्यादिभगणस्य ॥ २१ ॥[2]
परि[3]वर्त्ता खचतुष्टय शरा[5]ब्धिरसगुणयम द्विवसु
तिथयः । १५८२२३ । ६४५००००[1]
रविभगणोना भानोः सावन दिवसाः कुदिवसास्ते[2] ॥ २२ ॥
[3]४३२०००००००
१५७७९१६४५००००

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२१. (घ) १. व्रजनोश्विन्यादि for (व्रजतोऽश्विन्यादि)

२. (१९, २०. तथा २१ श्लोकों के अन्तर्गत आई हुई संख्याएं यहाँ एक ही स्थान पर दे दी गई हैं)

(ग) ३. स्त्रिनंदवसव for (स्त्रिनंदवसवः)

४. संख्या मूल में लुप्त हैं, परन्तु टीका में अंकित हैं।

५. संख्या मूल में लुप्त हैं, परन्तु टीका में ५८५ अंकित हैं।

(च) वि० श्लोकांकित संख्याएं लुप्त हैं।

१. (१९, २०, तथा २१ वें श्लोकों के अन्तर्गत आई हुई संख्याएं यहाँ एक ही स्थान पर अंकित हैं यथा ४८०, ४८८१०५८५८ २९२ ३३२ ८५५ ६५३ ॥ ४१ : २३२३१११६८ २६७ ॥ ५२१, ६३ ८९३, ५८४।

२२. (घ) १. १५८२२३ ॥ ६४५०००० (च) १५८२२३ ॥ ६४५०००

२. सावा (ग) सा वा (ख) (च) दिवसां वा for (दिवसास्ते)

(ग) ३. परिवर्त्ताः (च) for (परिवर्त्ता)

४. यह संख्या यहाँ नहीं दी गई है।

(क) ५. शरब्धि for (शराब्धि)
वि० मूल की तीनों संख्याएं लुप्त हैं, परन्तु टीका में क्रमशः अंकित हैं।

रविभगणा रव्यब्दा द्वादशगुणिता भवन्ति रविमासाः ।
५१०४००००००० [4]

भगणांतरं[2] रवींद्वोः[3] शशिमासाः [1]५३४३३३०००००
सूर्यमासोनाः ॥ २३ ॥

अधिमासाः १५९३३००००० शशिमासास्त्रिंशद्गुणिता
[1]१६०२९९९०००००० भवन्ति शशिदिवसाः ।

शशिसावनदिवसान्तरमवमानि तिथिः शशांकदिनम् ॥ २४ ॥
[2]२५०८२५५०००

सावन[1]मुदयादुदयो[5] भानां चार्क्षं[2] नृवत्सरोर्कश्च[3] ।
पितृदिवसाः[4] शशिमासा दिव्यानि दिनानि रविभगणाः ॥ २५ ॥

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२३. (घ) १. यह संख्या यहाँ श्लोक की समाप्ति के उपरांत रक्खी गई हैं। (ग) (च)

(क) २. भगणांतर (च) for (भगणांतरं)

३. रवींदोः for (रवींद्वोः)

४. संख्या मूल में लुप्त है, परन्तु टीका में अंकित है।

१. मूल में संख्या लुप्त है, परन्तु टीका में अंकित है।

(च) ३. रविंदोः for (रवींद्वोः)

(ख) "रविभगणारव्यब्दा द्वादशगुणिता भवंति ।
रविमासाः भगणांतरे रवींद्वोः शशिमासाः सूर्यमासो ना ॥ २३ ॥"
यह श्लोक अधिक है।

(ङ) यह श्लोक अंकित है।

२४. (घ) १. यह संख्या यहाँ पहली पंक्ति के तमाप्त होने पर लिखी गई हैं (ग) (च)

२. २५०८२५५०००० for (२५०८२५५०००)

(क) मूल की तीनों संख्याएं लुप्त हैं, टीका में क्रमशः निम्नांकित हैं—
५३४३३३०००००, १६०२९९९०००००००, २५०८२५५००००

२५. (घ) १. सवन (च) for (सावन)

२. चार्क्ष्यं (ग) (क) वार्क्षं (ख) वक्षा for (चार्क्षं)

३. कर्ब्दः (ग) (क) (ख) कर्ब्दः for (कर्श्च)

(ग) ४. पितृदिवसा for (पितृदिवसाः)

(क) ५. दुदयं for (दुदयो)

(च) २. चार्क्ष्यं for (चार्क्षं) ३ क्रश्चः for (कर्श्च)

कल्प परार्धमनवः षट्कस्य गताश्चतुर्युगत्रिघनाः ।
त्रीणि कृतादीनि कालो गोगैकगुणाः शकान्तेऽब्दाः ॥ २६ ॥
१८५२८१६०००,११६६४००००,३१७९

२६. (घ) १. परार्द्ध (ग) कल्पापरार्द्ध ४३२००००००००००००००००००००००००० for (परार्धमनवः)
२. घ्रता (ग) घनः ११६६४०००० (क) घनः (ख) त्रिघनम् for (घनाः)
३. काले (ग) कले (क) कलौ (ख) कलेर्गोगैकगुणः for (कालो गोगैकगुणाः)
४. गोगैः (ग) र्गोगैक गुणः ३१७९ for (गोगैकगुणाः)
५. अतिरिक्त संख्या + ३८८८००० +
(ग) ६. १८५२४१६०० for (१८५२४१६०००)
७. गताश्वचतुर्युग for (गताश्चतुर्युग)
८. + ३८८८००० +
(वि० — उपर्युक्त संख्याएं 'ग' में श्लोक के अन्तर्गत ही हैं)
(क) १. परार्द्ध for (परार्ध)
९. ऽन्धः for (ऽब्दाः) (ख) सकनृपांते ऽब्दाः for (शकान्ते ऽब्दाः)
वि० मूल में संख्याएं लुप्त हैं, टीका में क्रमशः हैं—
१०००००००००००००००००, २७, १७२८०००, ३१२९६०००,
८६४०००, ३१७९.
(ख) १. कल्पपरार्द्ध for (कल्पपरार्ध)
(च) १. परार्द्ध ७, गताश्चतुर्युगत्रिघ्रत for (गताश्चतुर्युगत्रिघनाः)
३. काले for (कालो) ४ गोगैः कगुणाः for (गोगैकगुणः) ९ शकांतेऽब्दाः for शकांतेऽब्दाः)
(घ) ग्रहनक्षत्रोत्पत्ति ब्रह्मदिनादौ दिनक्षये प्रलयः ।
यस्मात्कल्पस्तस्माद्ग्रहगणिते कल्पयाताब्दाः ॥ २७ ॥
(वि०) (यह श्लोक १९०२ ई० में प्रकाशित 'ब्राह्मस्फुट सिद्धान्त' में नहीं है। यह संस्करण क्वींस कालेज के प्रोफेसर महामहोपाध्याय सुधाकर द्विवेदिकृत नूतन-तिलक समेत 'मैडिकल हाल प्रैस में मुद्रित हुआ — ब्राह्मस्फुट सिद्धान्त के साथ इसमें ध्यानग्रहोपदेशाध्याय' भी प्रकाशित है)
(वि०) यह श्लोक (ग) तथा (क) पांडुलिपियों में निम्नांकित पाठान्तरों के साथ उपलब्ध है—
(ग) १. ग्रहः for (ग्रह); (क) २. + स्युः +

नवनगशशिमुनिकृतनवय[1] नगनन्देन्दव:[4]
[2]१९७२९४७१७९ शकनृपांते ॥
[5]सार्धमतीव[3] मनूनां सन्धिभिराद्यन्तरान्तगतैः ॥ २७[6] ॥
[4]अधिकः स्मृत्युक्तमनोरार्यभटोक्तश्चतुर्युगेन मनुः ।
अधिकं विशांश[2] युतैस्त्रिभिर्युगैस्तस्तस्य[1] कल्पगतम् ॥ २८ ॥
[3]१८६१२७१९
कल्पगताब्द[1]द्वादशघात[2]श्चैत्रादिमासयुक्तोऽधः[4] ।
गुणितो युगाधिमासै रविमासाप्ताधिमासयुतः[3] ॥ २९ ॥

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२७. (घ) १. यमांगतांदेन्दव (ग) यमाग (ख) यमागनंदेदवः for (यनगनन्देन्दवः)
२. यह संख्या यहाँ श्लोक के अन्त में दी है, (ग)
(ग) ३. सार्ध प्रतीत (ख) सार्धमतीत (च) सार्द्धमतिव for (सार्धमतीव)
(क) १. यमागणंदेदंवः for (यनगनन्देन्दवः)
२. यह संख्या मूल में लुप्त है। टीका में उपलब्ध है।
(च) १. यमांगतं for (यनगनन्)—"देन्दवः" उत्तरार्ध का आरंभ है
४. उत्तरार्ध का आरंभ—देंदवः for (देंदवः)
५. +शकनृपांते+
६. +१९७२९४७१७९+

२८. (घ) १. युगैस्तस्य कल्पगतम् for (युगैस्तस्तस्य कल्पगतम्) (ग) (क) (ख)
(ग) २. विंशांक (क) (विशांश)
३. १९८६१२३१७९ for (१८६१२७१९)
(क) ३. यह संख्या मूल में लुप्त है, टीका में निम्नाँकित है—१९८६१२३७९
(ख) ४. अधिकस्मृत्युक्त for (अधिकः स्मृत्युक्त)
(च) ३. स्मृत्युत्त for (स्मृत्युक्त)

२९. (घ) १. ब्दा for (ब्द) (च) कल्पगताब्दा for (कल्पगताब्द)
२. घाता for (घातश्) (क)
(ग) ३. युताः (for युतः)
(क) ४. युक्तोऽध । (ख) युक्तोघ (च) युक्तोघः for (युक्तोऽधः)
(च) २. द्वादशघातस्चित्रादि for (द्वादशघातश्चैत्रादि)

त्रिंशद्गुणस्तिथियुतः पृथग्युगावमगुणो युगेंदुदिनैः ।
भक्तफलावमोनोऽर्कसावनाहर्गणोऽर्कादिः ॥ ३० ॥
इष्टग्रहभगणगुणादहर्गणात् कल्पसावनद्युहृतात् ।
भगणादि फलं मध्यो लंकायां भास्करौदयिकः ॥ ३१ ॥
आनयति दिवसवारं स्मृत्यविरोधेन मध्यमानथवा ।
ब्राह्मादन्यैस्तन्त्रैरार्यभटाद्यैर्न्न कश्चिदपि ॥ ३२ ॥
जगति तमोभूतेऽस्मिन् सृष्टयादौ भास्करादिभिः स्पृष्टैः ।
यस्माद्दिनप्रवृत्ति दिन वारोऽर्कोदयात्तस्मात् ॥ ३३ ॥

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३०. (घ) १. विमानो (च) for (वमोनो)
२. सावनोः (ग) सावनो (क) सावनो (ख) (च) for (सावना)
३. हर्ग्रणो (ग) (क) ऽहर्गणो (च) for (हर्गणो)
(ग) ४. +३०+
५. भक्तः (क) (ख) for (भक्त)
६. ऽर्कादि for (ऽर्कादिः)
(क) ४. त्रिशत् गुणास्तिथियुतः for (त्रिंशद्गुणस्तिथियुतः)
(ख) ५. मगुणे for (भक्तफला)
(च) ६. ऽर्क्क for (ऽर्क) ६ ऽर्क्कादिः for (ऽर्कादिः)
३१. (घ) १. भास्करोदायिकः । (ग) (च) for (भास्करौदयिकः)
(ग) २. बधादहर्गणात् for (गुणादहर्गणात्)
(क) १. भास्करोदयिकः for (भास्करौदयिक.)
(ख) ३. इष्टग्रहणभगणा for (इष्ट ग्रहभगण)
(च) ४. दर्गणात् for (दहर्गणात्)
५. द्युहृता for (द्युहृतात्)
३२. (ग) १. र्नं कश्चदपि for (र्न्नं कश्चिदपि) (क) (ख) र्न for (र्न्नं)
(क) २. ब्रह्मा (ख) for (ब्राह्मा)
३३. (घ) १. तसोभूते for (तमोभूते) (ख) तमोभूतो for (तमोभूते)
२. सृष्टैः (ग) (क) (च) for (स्पृष्टैः)
(ग) ३. दिनवारो (ख) for (दिनवारो)
(ख) ४. ऽर्कोदयस्तस्मात् for (ऽर्कादयात्तस्मात्)
(च) १. तसोभूते for (तमोभूते) ३. द्दिनवारोर्क्का for (दिनवारोऽर्को)

लङ्कासमयाम्योत्तररेखायां[1] भास्करोदये मध्याः ।
देशान्तरोनयुक्ता रेषा[2] प्रागपरदेशेषु ।। ३४ ।।
दिनवारादिः पश्चादुज्जयनी दक्षिणोत्तरायाः[1] प्राक ।
देशान्तरघटिकाभिः पश्चात्प्राक्[2] भवति रव्युदयात् ।। ३५ ।।
भूपरिधिः[4] खखखशरारेखा स्वाक्षान्तरांश[6] संगुणिताः[5] ।
५००००[1]
भगणांश ३६०[2] हृता फलकृतिहीनो[3] देशान्तरस्य कृतिः ।। ३६ ।।[7]
शेषपदगुण[1]भुक्तिर्भूपरिधि हृता[2] कलादि[3] लब्धमृणम् ।
उज्जयनी याम्योत्तर रेखायाः[4] प्राग्धनं[5] पश्चात् ।। ३७ ।।

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३४. (य) १. रेषायाँ for (रेखायां)
(ग) २. रेखा (क) (ख) for (रेषा)

३५. (घ) १. दक्षणोत्तरायाः for (दक्षिणोत्तरायाः) (च)
२. प्राग्भवति (ग) (क) (च) for (प्राक्भवति)

३६. (घ) १. ५००० (ग) for (५००००)
२. 'हृता' से पूर्व दी गई ३६० की संख्या यहाँ 'हृता' के पश्चात् दी गई है ।
(ग) (ख) हृल (च)
(ग) ३. हीना (क) (ख) for (हीनो)
(क) ४. परिधि for (परिधि)
५. संगुणिता for (संगुणिताः)
वि० श्लोकान्तर्गत संख्याएं लुप्त हैं । (ख)
(ख) ६. स्वक्षांतरांस for (स्वाक्षांतरांश)
(च) ३. हिनो for (हीनो)
७. क्रमसंख्या लुप्त

३७. (घ) १. गुणा (ग) (क) (च) for (गुण)
२. परिधिताकलादि for (परिधि हृताकलादिं)
(ग) ३. कलादिलब्धमृणम् for (कलादिं लब्धमृणम्)
(क) ४. रेखाया for (रेखायाः)
५. प्रागृणं धनं (ख) for (प्राग्धनं)
(च) ३. कलादिलब्धमृणं for (कालादिंलब्धमृणम्)

मध्य[1]ग्रहे स्फुटे[2] वा भूप[5]रिधिहृतात्पदाद् गुणात् षष्ट्या[7] ।
लब्धं घटिका[3]द्यथवा कर्म तिथि[6] ऋण[4] धनं ग्रहवत् ॥ ३८ ॥
कल्पगताब्दा गुणिता रूपाष्ट[1]जिनैर्नवाग्नि[3]सतगैः
२४८१७७३९ ।
खखरसनवभि ९६००[2] भक्ता[4] दिनावमान्यं[5]शकाः शेषाः ॥ ३९ ॥
तद्दिकगुणा[1] १० योगा[3]दर्धिस्त्रिशता धृता[2]ल्लब्धम् ।
शेषास्तिथयः शुद्धि[4]दिनानि विकलं दिनांशेभ्यः ॥ ४० ॥

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३८. (घ) १. मध्ये (ग) (च) for (मध्य)
२. स्फटे (च) for (स्फुटे)
(क) ३. 'द्य' लुप्त है—'छूट गया' का चिह्न है, आगे 'थावा' है।
४. मृण for (ऋण)
(ख) ५. भूपरिहृतात् for (भूपरिधिहृतात्)
६. तिथिषु for (तिथि)
(च) ७. +॥ ६ ॥

३९. (घ) १. जनैर्नवाग्नि for (जिनैर्नवाग्नि) (ग) जिनै २४२४८१
२. यह संख्या यहाँ 'भक्ता' के पश्चात् अंकित है।
(ग) ३. सप्तनगैः ७७३९ (क) सप्तनगैः (ख) for (सतगैः)
४. यहाँ 'भक्ता' से आगे ९६०० की संख्या है।
(क) ५. मानांशकाः for (मान्यंशकाः)
(च) १. रूपाथजनैर्नवाग्नि for (रूपाष्टजिनैर्नवाग्नि)

४०. (घ) १. गुणाः for (गुणा १०) (ग) तद्दिग्गुणा १० ब्द for (तद्दिकगुणा १०)
२. हृता (ग) (क) हृताल्लब्धां (ख) हताल्लब्धम् for (धृताल्लब्धम्)
(ग) ३. दधिमासास्त्रिशता (क) (ख) दधिमासा for (दर्धिस्त्रिशता)
(क) १. तद्दशगुणाब्दयोगा for (तद्दिकगुणा १० योगा)
(ख) १. तद्दिग्गुणाब्द for (तद्दिकगुणा १०)
४. र्दिनानि for (दिनानि)
(च) १. तद्दिकगुणाः for (तद्दिकगुणा)
२. द्धताल्लब्धं for (धृताल्लब्धं)

कल्पगताक्षदिनयुतैः सूर्याद्योऽब्दाधिपो गताब्दभगणवधः ।
कल्पाब्दभूतो गणादिसध्यमः सूर्यभगणान्ते ॥ ४१ ॥
चैत्रसिताद्यास्तिथयः शुद्धिविहीनाः पृथग्गुणा रुद्रैः ।
अवमांशेभ्यो यमनवरस ६९२ गुणितेभ्यो विभक्तेभ्यः ॥ ४२ ॥
स्वछेनफलयुता हृतास्त्रिखागैः ७९३ फलावमविहीनाः ।
रविमेषादि द्युगणो मुनिहृत् शेषोब्दपत्यादिः ॥ ४३ ॥

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४१. (घ) १. सूर्यो (च) for (सूर्या)
२. योगताब्द for (पोगताब्द) (ग) ऽब्दभगण (क) धियोऽब्दभगण for (धिपोगताब्दभगण)
(ग) ३. गताब्ददिनयुतैः for (गताक्षदिनयुतैः) (क) गताब्द for (गताक्ष)
४. हृतो (क) (ख) हृतो for (भूतो)
५. भगणादि (क) (ग) भगणादि for (गणादि)
(ख) ३. कल्नगताब्ददिनयुतैः for (कल्पगताक्षदिनयुतैः)
२. धिपोब्धभगणवधः for (धिपोगताब्द भगणवधः
(च) ६. अवग्रहचिह्नलुप्त

४२. (घ) १. प्रथगुणा (च) for (पृथग्गुणा)
(ग) २. गुणिते विभक्तेभ्यः for (गुणितेभ्यो विभक्तेभ्यः)
(क—यहां के मूलपत्र उपलब्ध नहीं हैं)
(च) ३. रुद्रै for (रुद्रैः)

४३. (घ) १ त्रिखगैः for (त्रिखागैः) (ख) हृतास्त्रिखागैः for (हृतास्त्रिखागैः)
२. ७०३ (ग) for (७९३)
३. फलाऽवम for (फलावम)
४. मेखादि (ग) (च) for (मेषादि)
(ग) ५. स्वच्छेदेन ९६०० (ख) स्वछेदन for (स्वछेन)
(क) (क—यहां का मूलपत्र उपलब्ध नहीं है)
(ख) ६. मुनिहत for (मुनिहृत्)
(च) १. हृतास्रखगैः for (हृतास्त्रिखागैः) ३ फलाऽवमविहीनाः for (फलावमविहीनाः)
६. मुहृत for (मुनिहृत)

द्युगणात्सप[3]त्यंशं स्वनवार्कांशाधिकं[1] १२६ विशो[4]ध्यांशाः ।
मध्याः सूर्यबुधसिताः[2] शीघ्रोच्चं कुजगुरुशनीनाम् ।। ४४ ।।
त्रिगुणमवमाशेषं[2] विभजेद्गुण[5]सप्त[1]शशिः[4] १७३ ।
पृथगधिकोऽर्को[6] रविगुणतिथ्यंशैः[3] संयुतश्चन्द्रः ।। ४५ ।।
एकादशलिप्तांशा[2] भौमः शरसप्तवसुभिरिन्दुयमैः[3] ।
कृतगुणितोध[4] द्युगणोशाः[1] पंचरसै[5] षट्क बुधशीघ्रम् ।। ४६ ।।

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४४. (ग) १. यहाँ '१२६' संख्या नहीं दी गई ।
(क) क—यहाँ का मूलपत्र उपलब्ध नहीं है ।
(ख) २. सिता for (सिताः)
(च) ३. सप्रत्यंशं for (सपत्यंशं) ४ वशोध्यांशाः for (विशोध्यांशा)

४५. (घ) १. सप्तशशिराप्तांशैः (ग) सप्तशशिभिराप्तांशैः for (सप्तशशिः १७३)
(ग) २. भावशेषं (च) for (भाशेषं)
(क) (क—यहाँ का मूल पत्र उपलब्ध नहीं है ।
(ख) १. सप्तशशिभिराप्तांशैः for (सप्तशशिः १७३)
३. रविगुणातिथ्यंशैः for (रविगुणतिथ्यंशैः)
(च) १. सप्तशशिभिः for (सप्तशशिः १७३)
४. +सप्तांशैः+
५. 'ण' लुप्त
६. र्क्का for (ऽर्को)
३. रविगुणतिथ्यशै for (रविगुणतिथ्यंशैः)

४६. (घ) १. गणांशाः for (गणोशाः) (ख) द्युगणांशाः for (द्युगणोशाः)
(ग) २. लिप्तांशाः (ख) लिप्ताशन् for (लिप्तांशा)
३. ८७५ रिपुयमैः ।। २१ ।। for (रिन्दुयमैः)
४. गुणितो द्युगणोंशाः for (गुणितोधद्युगणोशाः) (ख) कृतगुणिता for (कृतगुणितोध)
५. रसैः ६५ (ख) रसैः (च) for (रसै)
(क) (कि—यहां का मूलपत्र उपलब्ध नहीं है)
(च) ३. रिन्दुयमै ११ for (रिंदुयमैः)
१. द्युगणोंशाः for (द्युगणोशाः)

द्यु गणेषु[६] बधो लिप्ताजीवः कृतशरगुणे[१]: शरका[२]लोनः ॥
भागकलाः सित[४]शीघ्रं वि[५]षयैर्वसवो द्विषष्टचाष्टौ[३] ॥ ४७ ॥
द्विगुणा[१]: कला[२]: दिनगणस्तिथिरामैर्द्धे[३] काल[६] च सूर्यसुतः[८] ।
नवभिर्भागः साग[४] ११२१ खशून्यवेदैश्चन्द्रो[७]च्चम्[५] ॥ ४८ ॥

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४७. (ग) १. गुणैः (ख) (च) for (गुणेः)

२. कलोनः । ३५४ । ५ ॥ for (कालोनः) (ख) शरकलोनः for (शरकालोनः)

३. ष्टौ ।८।८। for (ष्टौ) (ख) द्विषष्ठमासौ for (द्विषष्टचाष्टौ) ।५।६२

(क) (कि—यहां का मूलपत्र उपलब्ध नहीं है।

(ख) ४. शित for (सित)

५. विषवै for (विषयै)

(च) ६. द्युगणेशु for (द्युगणेषु) ३ द्विषष्टचष्टौ for (द्विषष्टचाष्टौ)

४८. (घ) १. द्विगुणः for (द्विगुणाः)

२. कला for (कलाः) (ख) कलादिनगणास् for (कलादिनगणास्) (च) कला for (कलाः)

३. द्धे कले । ३१५ । २ । for (द्धे काल)

४. सागर—for (साग ११२१) (यहां कोई संख्या नहीं दी गई है) (ख) सागर

५. + । ६ । १ । ४००४ । १० । +

(क) (क यहां का मूलपत्र उपलब्ध नहीं है)

(ख) ६. कले for (काल)

७. श्चचन्द्रोच: for (श्चन्द्रोच्चम्)

(च) ८. +१११+

भागो[४] नन्दशशांकैः ११६८[५] शशिशून्य[७] ८७५२१ स्वरयामै[१]

२७।६४००४।०११

रविमंडलांतिकयुता मध्य[२] भगणान्ति[६] ३५६[३] का[८]शेषाः ।। ४९ ।।

पादार्द्ध विपाददिनै रात्र्यर्द्धास्तमय[१]दिनदलौदयिकाः । ३१५ ।

ऊनीकृत्वा तिथयो देशान्तरनाडिका[२]नयुताः ।। ५० ।।

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४९. (घ) १. यमैश्च शशिपातः (ग) यमैश्च ७७०१ शशिपातः for (यामै २७। ६४००४।०११)

२. मध्या (ग); (ख) for (मध्य)

३. ३५८ for (३५६) (ग) यहां यह संख्या नहीं दी गई।

(ग) ४. भोगानन्द for (भागोनन्द)

५. १९ for (११६८)

६. भगणांतिका शेषाः for (भगणान्ति ३५६ का शेषाः)

(क) (क—यहां का मूलपत्र उपलब्ध नहीं है।)

(ख) ७. सूर्य for (शून्य)

१. यमैश्च शशिपातः for (यामै २७। ६४००४।०११)

(च) १. स्वरयामैश्च शशिपातः for (स्वरयामै)

३. ३५६। ५। for (३५६)

८. काः for (का)

५०. (ग) १. दलोदयिकाः for (दलौदयिकाः)

२. नाडिकोनयुताः for (नाडिकानयुताः) (ख) नाडिकेन for (नाडिकान)

(क) (कि -यहां का मूलपत्र उपलब्ध नहीं है)

(ख) १. दिनदलौदयिक्ता for (दिनदलौदयिकाः)

कलिगतशुद्धिः[1] प्राग्वछुक्राद्योब्धाधिपो[7]क्षभगण[1] वध्यत[2]क्षितिजस्य[3] ।
ख[4]त्रिचाष्ट रस[5]सप्त वसुरवाग्निवेद[8]युतात् ॥ ५१ ॥

४३०८७६८००००

बुधशीघ्रस्य खरवांबर रस[1]नन्द दृष्टो[3]ष्ट वसुयमो दधिभिः ।[4]

४२८८८९६००

खचतुष्टययमशरगुण शशिवेदैः ४३१३५२[4]००००

सुरेन्द्रगुरोः ॥ ५२ ॥

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५१. (घ) १. ब्दा for (क्ष) (ग) ब्द भगणबधात् for (क्षभगणवध्यत) (ख) ब्द for (क्ष)
२. वध्यत् for (वध्यत) (पहली पंक्ति का अन्तिम शब्द) (ख) वधात् for (वध्यत)
३. 'क्षितिजस्य' दूसरी पंक्ति का आरम्भिक पद । (ग) (ख)
४. खत्र (ग) खत्रयाष्ट (ख) खत्रयाष्ट for (खत्रिचाष्ट)

(ग) ५. रसप्त for (रससप्त)

(क) (क—यहां का मूलपत्र उपलब्ध नहीं है।)

(ख) ६. शुधि for (शुद्धिः)
७. द्दधियो for (ब्दाधिपो)

(च) ७. छुक्राद्योब्दाधियो for (छुक्राद्योब्धाधिपो)
२. वध्यत् for (वध्यत)
४. खत्रचाष्ट for (खत्रिचाष्ट)
८. दैदयुतात् for (वेदयुतात्)

५२. (घ) १. रसनं दृष्टो (च) for (रसनन्द दृष्टो)
२. यह संख्या यहाँ श्लोक के अन्त में दी है। (ग) (च)

(ग) ३. नन्दाष्टाष्ट (क) (ख) नन्दाष्टा for (नन्ददृष्टोष्ट)
४. ४२८८८९६००० for (४२८८८९६००)

(क) ४. मूल में संख्या लुप्त है। टीका में ४२८८८९६००० अंकित है।
२. मूल में संख्या लुप्त है, टीका में ४३१३५२००० अंकित है।

भार्गव[1]शीघ्रस्यांबर खखाष्टं[3] वेदाब्धि[5]वेदखाग्नि[6] कृतैः ४३०४४८०००
भास्कर[7] सुतस्य खत्रय रविगुणशर[2]खगुण[4] समुद्रैः ॥ ५३ ॥

४३०५३१२०००

शून्य[7]चतुष्टय पक्षेदुं[2] रामगुण नवभिरर्कमंदस्य । ६३३१२००००
इन्दोः[3] खमय[1] यमशर[4]नव पंचव्योम[6] शरचन्द्रैः ॥ ५४ ॥ [5] १५०५६२०००
खत्रय यमनवपंचाष्टरामधृतिभिः शशांकपातस्य । १८३८५६२०००
कल्पगतभगण[1]घातात् कुजादिमंदोच्चपातानाम् ॥ ५५ ॥

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५३. (घ) १. भाग्रव (च) for (भार्गव)
२. शरखद for (शरखगुण) (ख) शरखदहन सुमुद्रैः for (शरखगुणसमुद्रैः)
(ग) ३. खखाष्ट for (खखाष्टं) (क) (ख) खाखाष्ट for (खखाष्टं)
४. दहनसमुद्रैः (क) for (खगुणसमुद्रैः)
(ख) ५. वेदाश्च for (वेदाब्धि)
६. वेदखाब्दि for (वेदखाग्नि)
७. भागस्कर for (भास्कर)
(च) ३. खखाष्ट for (खखाष्टं)
४. खद for (रवगुण)

५४. (घ) १. त्रयं for (खमय) (ख) त्रयमशर for (खमययमशर) (च) खत्रये for (खमय)
(ग) २. पक्षेन्दु (क) (च) for (पक्षेदुं)
३. चन्द्रसमः शून्यत्रय for (इन्दोः खमय)
४. यमशनवशरखशरचन्द्रैः for (यमशरनवपंचव्यो मशरचन्द्रैः)
५. १५०५६५२००० (च) for (१५०५६२०००)
(क) ३. चंद्रमसः शून्यत्रय for (इन्दोः खमय)
६. शरख for (पंचव्योम)
वि० मूलांकित दोनों संख्याएँ मूल में नहीं है। टीका में अंकित हैं।
(ख) ७. सून्य for (शून्य)

५५. (क) मूल में संख्या उपलब्ध नहीं। टीका में अंकित है।
(ख) १. गणोघ्ययातात्कुंजादि for (गणघातात् कुजादि)

भगणादिकल्पवर्षै[5] लब्धं[1] रविमंडलान्तिका[6]मध्या[4] ।
मेषादि[2]द्यु गुण[3]फलाधिका भवन्तीष्टदिनमध्याः ॥ ५६ ॥
शुद्धीश ११ बधे शुद्धे[1]देवमशेषात् सावनद्युगण शुद्धिः[4] ।
व्येकावमं[2] गृहीत्वा गुणस्व[3]मुने युतान्न[5] शुध्यति[6] चेत् ॥ ५७ ॥

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५६. (घ) १. लब्धम् for (लब्धं) (ग) (क) (ख) लब्ध for (लब्धं)

२. मेखादि for (मेषादि)

३. द्युगण (ग) (क) for (द्युगुण)

(क) ४. मध्याः (ख) मध्यः (च) मध्य for (मध्या)

(ख) ५. वर्षैः for (वर्षै)

६. लान्तिको for (लान्तिका)

(च) १. ब्धं for (लब्धं) ३ वक (द्यु) गण for (द्युगुण)

५७. (घ) १. शुद्धेऽवशेषा (ग) शुद्धेऽवमशेषात् (ख) शुद्धेवमशेषात् for (शुद्धेदेवमशेषात्)

२. व्येकामवं (ख) एकावमं for (व्येकावमं)

३. खमुने (क) खमुनि for (स्वमुने)

(ग) शुद्धीश के पश्चात् ११ की संख्या नहीं दी गई है । (क)

(क) १. ऽवमशेषोत्सावन for (देवमशेषात्सावन)

४. सिद्धिः (ख) सुद्धिः for (शुद्धिः)

(ख) ५. युतानि for (युतान्न)

६. सुध्यति for (शुध्यति)

(च) १. शुद्धेइवमशेषात् for (शुद्धेदेवमशेषात्)

२. व्येकामवं for (व्येकावमं)

चैत्रसिताद्यो[५]ब्द पति[१]द्धूनाया दिनाब्दरूपयुतेः ।
तद्युगणा[६]दिनवारान्[२] मुहु[४]र्मध्यमा[३] प्राग्वत् ॥ ५८ ॥
अकृतार्यभटः शीघ्र[७]गमिन्दु[३]च्चं पातमल्पगं[५] स्वगतेः[१] ।
तिथ्यन्तग्रहाणानां[४] घुणाक्षरं[२] तस्य संवादः[६] ॥ ५९ ॥

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५८. (घ) १. शुद्धच्यूनाया for (पतिद्धूनाया) (ग) (क) पतिः शुद्धच्यूनाया for (पतिद्धू-नाया)
२. वारन् (ग) वारः (क) वारः (ख) वारः for (वारान्)
३. मध्यमा (ग) (क) मध्यमा for (र्मध्यमा)
४. मुह्यू (शुद्धच्यू) (ग) शुद्धच्यूना (क) शुद्धचवमा for (मुहुर्मध्यमा)
(ग) ५. चैत्रसिताद्योद्योब्दपतिः for (चैत्रसिताद्योब्दपति)
(क) ६. तद्युगणात् for (तद्युगणा)
(ख) १. पतिः शुध्यूनाया for (पतिद्धूनाया)
४. शुध्यूना for (मुहुर्मध्यमा)
(च) १. पतिः शुद्धच्यूनाया for (पतिद्धूनाया)
६. तत् द्युगणा for (तद्युगणा)
३. मध्यमाः for (मध्यमा)

५९. (घ) १. स्वगतैः (ख) स्वगते for (स्वगतेः)
२. घुणाक्षरं (च) for (घुणाक्षरं)
(ग) ३. दूच्चं (क) (ख) दूवं for (दुच्चं)
(क) ४. ग्रहणानां (ख) (च) for (ग्रहाणानां)
५. मल्यगं for (मल्पगं)
६. 'संवादः' पद लुप्त है ! श्लोक तो 'तस्य' पर समाप्त है।
(च) ७. शिघ्र for (शीघ्र)

(घ) खखखार्क १२००० हृताब्देभ्यो, गतगम्यात्पाः खशून्ययमल २०० हृताः ।
लब्धं त्रि ३ सायक ५ हतं कलाभिरूनौ सदार्केन्दू ॥ ५९ ॥
शशिवत् जीवे द्वि २ हतं, चन्द्रोच्चे तिथि १५ हतं तु सितशीघ्रे ।
द्वीषु ५२ हतं च बुधोच्चे, द्वि २ कु १ वेद ४ हतं च पात कुजशनिषु ॥ ६०
वि० उपर्युक्त दोनों श्लोक १९०२ ई० में प्रकाशित ब्राह्मस्फुटसिद्धान्त में "अतिरिक्त" हैं।

मध्यगतिज्ञं वीक्ष्य[१] श्री[३] षेणार्यभटविष्णु[५]चन्द्रज्ञाः[४] ।
सदसि न भवन्त्यभिमुखाः सिंहं दृष्ट्वा[२] यथा हरिणाः[६] ॥ ६० ॥
युगभगणमान याता[५]हर्गण[१] दिनवारमध्यमाद्येषु ।
मध्यमगति द्विषष्टचार्याणां[२] प्रथम[३]कृतो[४] है ॥ ६१ ॥

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६०. (ग) १. वीक्ष for (वीक्ष्य)
२. दिष्ट्वा for (दृष्ट्वा)
(क) ३. श्रीहर्षेणार्य for (श्रीषेणार्य)
(ख) ५. विभुचन्द्राद्या for (विष्णुचन्द्रज्ञाः)
६. हरिणः for (हरिणाः)

६१. (घ) १. हर्ग्रण for (हर्गण)
२. द्विषष्ट्चार्यणां (ग) द्विषष्ट्चार्यां (क) द्विषष्ट्यर्याणां for (द्विषष्ट्चार्याणां)
३. प्रथमः कृतोध्यायः (ग) (क) प्रथमाः for (प्रथमकृतो है)
(ग) वि० + इति श्री ब्रह्मसिद्धाते मध्यमाधिकारः प्रथमः +
(ख) ५. यतो for (याता)
२. द्विषष्टार्याणां for (द्विषष्ट्चार्याणां)
(ख) की दृष्टि से ६३ श्लोक हैं, २३ वां अधिक है ।
(च) ३. प्रथमः for (प्रथम)
४. कृतोध्यायः for (कृतोहै)

॥ श्रीगणेशायनमः ॥ [५]

यस्मान्न मध्यतुल्यः [४] प्रतिदिवसं दृश्यते ग्रहो भगणे ।
तस्माद्[१] कल्पकरं वक्ष्ये[३] मध्यस्फुट[२]करणम् ॥ १ ॥
अर्धज्याभूयमला[१] मुनियमवेदा वसुऽनलषट्का[२] ।
रसकृतवसवः शशिपंचखेन्दवश्चन्द्रशरसूर्याः[३] ॥ २ ॥
षट्दधि[५]मनवो भूवाग्नि[३]रसशशांका मुनींद[४]वसुचन्द्राः[६] ।
इन्दुनवनन्दचन्द्रा[७] रसतिथय[१] यमला रविस्त्रियमाः[२] ॥ ३ ॥

१. (घ) १. सस्माद्द for (तस्माद्) (ग) तस्माद्दक् तुल्यकरं (क) तस्माद्दक् तुल्यकरं for (तस्माद्कल्पकरम्)
२. स्फुटं for (स्फुट) (ग) स्फुटीकरणम् (क) स्फुटीकरणम् for (स्फुटकरणम्)
(ग) ३. वक्षे for (वक्ष्ये)
(क) ४. मध्यम for (मध्य)
(ख) १. तस्माद्दक् तुल्यकरं for (तस्माद् कल्पकरं)
२. स्फुटीकरणम् for (स्फुटकरणम्)
(च) ५. "मंगलसूचक शब्द" लुप्त है !
१. तस्मात् द्द for (तस्माद्) २ स्फुटं for (स्फुट)

२. (घ) १. मनुयमला for (भूयमला (ग) (क) अर्धज्यामनुयमला for (अर्धज्याभूयमला)
२. वसुज्वलखट्काः (ग) (क) वसुज्वलनषट्काः for (वसुऽनलखट्का)
(ख) १. अर्धज्यामनुयमला for (अर्धज्याभूयमला)
२. वसुज्वलनषट्काः for (वसुऽनलखट्का)
३. चन्द्रममूर्या for (चन्द्रशरसूर्याः)
(च) १. अर्द्धज्यामनुयमला for (अर्धज्याभूयमाला)
२. वसुज्वलनषट्काः for (वसुऽनलषट्का)

३. (घ) १. तिधिय for (तिथय) (ग) (क) रसतिथि (ख) रसतिथि for (रसतिथय)
२. यम्नाः for (यमाः) (ख) for (यमाः)
(ग) ३. भूताग्नि (क) (ख) (च) for (भूवाग्नि)
४. मुनींदु (क) (ख) (च) for (मुनींद)
(क) ५. षडवब्धि for (षट्दधि)
६. चन्द्रा for (चन्द्राः)
(ख) ७. चन्द्राः for (चन्द्रा) (च) १. तिथि for (तिथय)

ऋतुनवखगुणाः[3] नवशरचन्द्रगुणाः[1] सप्तशून्ययमदहना[4] ।
द्विजिनगुणा स्त्रिरसरदा[5] खस[2] प्रयम छिद्रेषु[6] जिनाः ॥ ४ ॥[7]

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४ (घ) १. चन्द्रागुणा (च) for (चन्द्रगुणाः)
२. सप्त for (सप्त) (ग) सप्तयम वह्नयो व्यस्ताः ॥ ५ ॥ for (सप्रयम-छिद्रेषु जिनाः ॥ ४ ॥)

(ग) ३. गुणा for (गुणाः)
४. दहनाः for (दहना)
५. रदाः for (रदा)

(क) 'क' में अंकित नहीं। इसके स्थान में दूसरा श्लोक अंकित है जो अगले पृष्ठ पर दिया है।

(ख) यहां यह श्लोक अंकित नहीं है।

(च) २. सप्त for (सप्र)
६. छिद्रेशु for (छिद्रेषु)
७. क्रमसंख्या लुप्त ।

(क. ख. ग.) में अतिरिक्त श्लोक —

छिद्रेषु जिना कृतनव पंचयमा[1] दं[2] नंद चन्द्रमुनि पक्षाः ।
दन्ताष्ट्[5]यमागुणा[6] रामनवयमाः शशिख[3] रामाः ॥ ४ ॥
ऋतुनव खगुणा नवशरचंद्रगुणाः सप्तशून्ययमदहनाः ।
द्विजिन[4] गुणास्त्रिरसरदाः खसप्तयम वह्नयो व्यस्ताः[7] ॥ ५ ॥

(क) १. यमाः for (यमा)
२. 'दं' लुप्त पद है। (ख)
३. शशियमखरामाः ॥ ४ ॥ (ख) शिशिगुणाखराम for (शशिखरामाः)
४. जित for (जिन)

(ख) ५. दताष्ट for (दन्ताष्ट)
६. यमगुण for (यमागुण)
७. व्यास्ताः for (व्यस्ताः)

(च) वि० इस स्थान पर यह श्लोक लुप्त है।
पृष्ठ ८b पर नीचे की ओर अन्य लेख में "ऋतुनव.............से-खसप्रयम" तक विद्यमान है। इस पर क्रम संख्या कोई नहीं।

कृतनव पंचयमा[२] नन्द चन्द्र[३] दन्ताष्ट यमगुण[१] रामनवयमाः[४] ।
शशियम खरामाः[५] मुनिपक्षाः वह्नयो व्यस्ताः ॥ ५ ॥
मुनयोष्टयमास्त्रिरसा रुद्र[४] शशांकाः समुद्रमुनि[१]चन्द्राः ।
नववेदयमामुनिगुणा[३] हुताशना[२] वसुगुणसमुद्राः ॥ ६ ॥
रूपेन्द्रियेषवोरसनगर्तं[१]वश्चन्द्रशीतकरवसवः ।
वसुशरनन्दाः[३] सागररुद्रशशांकाः[२] नवागार्काः[४] ॥ ७ ॥
त्रिविषयवेदशशांकाःपंचत्रि[४]रसंदवोब्धियमधृतयः ।
अतिधृतिस्व[२]यमानवशशियमपक्षा[३] सागर द्विजिना[१] ॥ ८ ॥

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५. (घ) १. यमा (च) for (यम)
(ग) वि० यहां चौथे और पांचवें श्लोक की चारों पंक्तियों को कुछ भिन्न प्रकार से लिखा हे । (क)
(क) १. क+षट् छिद्रेषु जिना २४५९+
२. यमाः+२५९४+for (यमा)
३. चन्द्रमुनिपक्षाः २७१६ for (चन्द्रदन्ताष्ट)
१. यमाः+२८३२ for (यम) । इसके पश्चात् दूसरी पंक्ति प्रारम्भ
४. +२९३३+
५. +३०२१+
(ख) यहां पर यह श्लोक 'लुप्त' है ।

६. (ग) ३. गुण (च) for (गुणा)
(क) ४. रुद्राः for (रुद्र)
(च) २. कुताशना for (हुताशना)

७. (घ) १. र्त्ववश्चन्द्र for (र्तवश्चन्द्र)
(क) २. शशांका (च) for (शशांकाः)
(ख) ३. नन्दा for (नन्दाः)
४. नवागार्का for (नवागार्काः)

८. (घ) १. द्विजिनाः (ग) (च) for (द्विजिनाः)
२. स्व (क) (च) for (स्व)
(ग) ३. पक्षाः (क) for (पक्षा)
(ख) ४. भि for (त्रि)
(वि० देखिए पृष्ठ २६—सारणी के लिए)

रदरसयमला गुणवेदवसुयमाः षट्क विषय[3]शून्यगुणाः ।
खमुनिरसा[1] व्यासार्द्धं नवरदचन्द्रा जिनांश[4]य्याः ॥ ६ ॥ [2]२४।१३।२६

२१४	[1]१८८७	२९३३	७	५५१	१८२४
४२७	१९९१	३०२१	२८	६७६	२०१९
६३८	२१५६	३०९६	६३	८११	२२१९
८४६	२३१२	३१५९	१११	९५८	२४२४
१०५१	२४५९	३२०७	१७४	१११४	२६७२[3]
१२५१	२५९४	३२४२	२४९	१२७९	२८४३
१४४६	[2]२७१४	३२६३	३३७	१४५३	३०५६
१६३५	२८३२	३२७०	४३८	१६३५	३२७०

६. (घ) १. रदा (ग) रदा (क) (च) for (रसा)

२. २४ ॥ १३२६ for (२४।१३।२६) ॥ (ग) १३२६+॥ २१४[1] ॥ ४२७[2]
॥ ६३८[3] ॥ ८४६[4] ॥ १०५१[5] ॥ १२५१[6] ॥ १४४६[7] ॥ १६३५[8] ॥ १८१७[9]॥
॥ १९९१[10] ॥ २१५६[11] ॥ २३१२[12] ॥ २४५९[13] ॥ २५९४[14] ॥ २७१९[15] ॥
॥ २८३२[16] ॥ २९३३[17] ॥ ३०२१[18] ॥ ३०९६[19] ॥ ३१५९[20] ॥३२०७[21]॥३२४२[22]॥
॥ ३२६३[23] ॥ ३२७०[24] ॥ एतेक्रमस्थाः ॥ अत उत्क्रमस्थाः ॥ ७[1] ॥ २८[2] ॥
। ६३[3] । १११[4] । १७४[5] । २४९[6] । ३३७[7] । ४३८[8] । ५५१[9] । ६७६[10] । ८११[11] ।
। ९५७[12] । १११४[13] । १२७९[14] । १४५३[15] । १६३५[16] । १८२४[17] । २०१९[18] ।
। २२१९[19] । २४२४[20] । २६३२[21] । २८४३[22] । ३०५६[23] । ३२७०[24] । उत्क्रमज्या
इति ॥+

(ख) ४. जिनांशज्या for (जिनांशय्याः)

(सारणी) (घ) १. १८१७ (ग) (च) for (१८८७)
२. २७१९ (ग) (च) for (२७१४)
३. २६३२ (ग) (च) for (२६७२)
(क) यहां यह सब लुप्त हैं।

लिप्तास्तत्त्व[5]यमहृता २२५ लब्धं [1]द्याषष्ट्यंतराहृता छेषात् ।
तिथिकृति [6]२२५ [2]हृत्फलयुता [7]लब्धष[3]ष्ट्या [4]द्वा ग्रहणमेवम्[8] ॥ १० ॥
[7]ज्यां प्रोह्य [6]शेषगुणितास्[3]तत्त्वयमा [1]ज्यांतरा [4]धृतालब्धम् ।
[8]क्षेप्यं विशुद्धजीवा[2]संख्यातिथि [5]कृतिवधे चापम् ॥ ११ ॥

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१०. (घ) १. ज्याष्ट्यंतरा (ग) ज्याज्यांतरा (क) ज्याज्यांतरा (च) for (द्याषष्ट्यंतरा)
२. हृतात् (क) for (हृत्)
३. ष्ट्या (ग) ज्या (क) (ख) षष्ट for (षष्ट्या)
४. ज्या (ग) ज्या (क) (ख) ज्या for (द्वा)

(ग) ५. मलहृता (ख) यमाहृता for (यमहृता)
६. २२५ हृतात्फल for (हृत्फल)
७. लब्वं for (लब्ध)

(क) २. हृतात्फलयुतात् for (हृत्फलयुता)

(ख) १. लब्धद्याघृचां for (लब्धद्याषष्ट्यां)
८. ग्रहणमेव for (ग्रहणमेवम्)

(च) ६. २., २२५ हृतात्फलयुता for (२२५ हृत्फलयुता)
३. ष्ट्या for (षष्ट्या)
४. छा for (द्वा)

११. (घ) १. ज्यांतरो (क) ज्यांतरोद्धृता (च) ज्यांतरोधृता for (ज्यांतराधृता)
२. संक्ष्या for (संख्या)

(ग) ३. गुणितात्तत्वयमा २२५ for (गुणितास्तत्त्वयमा)
४. +न+
५. +२२५+

(क) ६. सेष (ख) सेष for (शेष)

(ख) ७. प्रयोज्यय for (प्रोह्य)
८. क्षेपं for (क्षेप्यं)

(च) ७. प्रोज्य for (प्रोह्य) ८. क्ष्येप्यं for (क्षेप्यं)

मध्याद्विशोध्य मंदं शीघ्रात्संशोध्य मध्यमं केन्द्रम् ।
अयुतिगता[1] यया यो[3] युति[4] पदेऽन्यथा बाहुकोटिज्ये ॥ १२ ॥
त्रिज्याहृता[4] भुजज्या २२७०[5] युगयुक्[6]परिधि द्व्यांतर[1] गुणाप्त्या[2] ।
युग्मांत[7] परिधिरधिको[3] हीनोऽधिकः हीनोधिकः[8] स्पष्टः ॥ १३ ॥
तद्गुणितेज्ये भांशैः ३६२ हृते[2] फले कोटिफलयुता त्रिज्या ३२७० ।
आद्यन्तयोर्निर्हीनो[1] पदयोर्द्वितृतीययोः[3] कोटिः ॥ १४ ॥

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१२. (घ) १. व्ययुयगतयेयोर्युजि (ग) अयुजिगतयेयोर्युजि for (अयुतिगतायययायो युति)

(क) १. अयुजिगतैर्योज्ययोर्युजि for (अयुतिगतायययायोयुति)

(च) १. अयुतिगतं for (अयुतिगता) २ या for (गो) ३ र्युति for (युति)

४. अवग्रहचिह्नलुप्त

१३. (घ) १. द्वयांतर (ग) द्वयांर (क) द्वयांतर (ख) द्वध्वयांतर for (द्वयांतर)

२. गुणात्प्त्या (ग) गुणाप्त्या for (गुणात्प्त्या)

३. परिधिको हीनो हीनाधिकः for (परिधिरधिको हीनोऽधिकः हीनोऽधिकः)

(ग) ४. ३२७० हृता (क) त्रिज्याहृता (च) for (त्रिज्याहृता)

५. यह संख्या अंकित नहीं ।

६. 'ऽधिकः' शब्द अंकित नहीं (क)

(क) ७. 'युग्मांतर for (युग्मांत)

(ख) ६. 'हीनोऽधिकः' पद लुप्त हैं

८. हीनाधिकः for (हीनोधिकः)

(च) ५. २७७० for (२२७०) २+८+

३. परिधिकोहीनो for (परिधिरधिको हीनोऽधिकः)

१४. (घ) १. विहीना (ग) विहीना (क) विहीना for (निर्हीनो)

(ग) २. हृंते (क) for (हृते)

३. द्वित्रितीययोः for (द्वितृतीययोः)

(ख) १. विहीनो for (निर्हीनो)

(च) १. विहीना for (निर्हीनो)

तद्भुजफल कृतियोगान्मूलं कर्ण[1]ः पदेष्वयुग्युक्षु[5] ।
स्वपरिधिगुणा[2] क्रमोत्[5]क्रमजीवा भांशै[3] ३६० र्हृतान्[4]मन्दे ॥ १५ ॥
क्षयधनधनक्षयास्तत्फलानि शीघ्रेऽन्यथा धनं धनयोः ।
ऋणमृणयोर्यो[2]गान्तरमृणधनयो[1]स्तुल्ययोः[3] शून्यं ॥ १६ ॥
तच्चापं मन्दफलं फलयोगान्तरवशाद्धनमृणं[3] वा ।
शीघ्रफलं तद्गु[1]णिताद्व्या[2]सार्द्धात् कर्णलब्धधनुः ॥ १७ ॥ ३२७०
देशान्तरे खम[1]ध्ये भुजफलचापे भुजांतरे च कृते ।
उन्मण्डलेऽर्क[2] चन्द्रौ स्पष्टौ रविचरदले क्षितिजे ॥ १८ ॥
अर्को[1]दयास्तमययोर्विना चरार्द्धेन रा[2]त्रिदिनदलयोः ।
न स्फुटमार्यभटोक्तं स्पष्टीकरणं स्फुटोक्तिरतः ॥ १९ ॥

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१५. (घ) १. कर्णं पटेष्वग्युक्षु: for (कर्णः पदेष्वयुग्युक्षु)
२. गुणाः (च) for (गुणा)
३. स्यांशे for (भांशै ३६०) (ग) हृताफलं मंदे for (हृतामन्दे)
४. मांदैः (क) हृतामांदो (ख) हृतामन्दे for (हृतान्मन्दे)
(क) ५. पदेष्वयुक् युक् स्यात् for (पदेष्वयुग्युक्षु)
(ख) ६. क्रमोक्रमजीवा for (क्रमोत्क्रमजीवा)
(च) १. कर्णपदेष्वयुक्षः for (कर्णः पदेष्वयुग्युक्षु)
३. ज्यां (भां) शै for (भांशै) ४ हृतामंदै for (हृतान्मन्दे)

१६. (घ) १. धनयोः for (धनयोस्)
(ग) २. योगोन्तर for (योगान्तर)
३. तुल्ययो for (तुल्ययोः)

१७. (घ) १. गुणुता for (गुणिताद्)
(ग) २. व्यासार्द्धत् (क) व्यासोर्द्धात् for (व्यासार्द्धात्)
(क) ३. मृणंवति for (मृणंवा)
(च) १. तद्गुणितोद् for (तद्गुणिताद्)

१८. (घ) १. स्वमध्यो (ग) स्वमध्यै (क) स्वमध्यौ (ख) स्वमध्यो for (खमध्ये)
(च) १. स्वमध्यो for (खमध्ये)
२. र्क्का for (ऽर्कं)

१९. (ख) १. अर्कोदयास्तममयोर्विना for (अर्कोदयास्तमययोर्विना)
२. राभि for (रात्रि)
(च) १. अर्क्कोदयास्तमययोर्विना for (अर्कोदयास्तमययोर्विना)

सूर्यस्य मनुद्वितयं त्रिंशोनं[४] दिनदलेन तस्य प्राक् । $\frac{१३}{४०}$[१]
तिथिघटिकाभिस्त्रयंशाधिकोनमूनाधिकं पश्चात्[५] । $\frac{२०}{२०}$ ।। २० ।।
द्यु[८]दले जिनलिप्तोनं दशनद्वितयं ($\frac{३१}{३६}$) द्विशर[५] ५२ कलोनु[६] प्राक्[१] ।[२]
पश्चाद्युतोनर्मिदोः[३] सूर्यवहृण[७] धन परिध्यंशाः[४] ।। २१ ।।

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२०. (घ) १. $\frac{१३}{४०}$।$\frac{१३}{४०}$ (ग) for ($\frac{१३}{४०}$)

२. तिथि +१५+(ग) for (तिथि)

३. त्र्यंशा (ग) स्त्रियशाधिकोन ।१४।०।।१३।२०।। for (स्त्रयंशाधिकोन)

(ग) ४. त्र्यंशोनं (क) for (त्रिंशोनं)

५. पश्चात् व for (पश्चात्)

(च) २. +१५+   १ संख्या लुप्त

३. त्र्यं $\frac{१३}{४०}$।।$\frac{१३}{४०}$।। शाधिको for (त्रयंशाधिको)

२१. (घ) १. कलोनं (ग) (क) (ख) कालोनं for (कलोनु)

२. यहां '५२' संख्या जो 'द्विशर' के बाद अंकित है, लिखी है।

३. मंदोः for (र्मिदोः)

(ग) ५. संख्या अंकित नहीं है।

६. संख्यां अंकित नहीं है।

(क) ७. सूर्याहृण for (सूर्यवहृण)

(ख) ८. द्युदलेतिन for (द्युदलेजिन)

(च) ६. संख्यालुप्त   १ कलोनं for (कलोनु)

२. +५२+   ७ सूर्यवहृण for (सूर्यवहृण)

तद्यु[3]दलपरिध्यंतर गुणाकृता[1] त्रिज्यया[2] स्वनतजीवा ।
ऊने धनमृणमधिके[4] दिनार्द्ध परिधौ[6] स्फुटः[5] परिधिः ।। २२ ।।
भुजफलचापं केन्द्रे षड्राश्यूने[1] खावृणं मध्ये ।
स्वभुजबल[2]चापमिन्दौ षड्राश्य[3]धिके धनं भवति ।। २३ ।।
देशान्तराद्यमेवं स्पष्टीकरणं दिनार्द्धपरिधिभ्याम् ।
कृत्वा तत्तिथ्यन्त[1] स्फुटपरिधिभ्यां स्फुटावसकृत् ।। २४ ।।

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२२. (घ) १. हृता (ग) (क) (च) for (कृता)

२. तृज्यया for (त्रिज्यया) (क) त्रिज्ययाश्च नतजीवा for (त्रिज्यया स्वनतजीवा)

(ग) यहां निम्नांकित संख्या अधिक है—

३१	३१	५२	३०	३२	३०
३६	३६		४४	२८	४४
				८	

(क) ३. तत्

४. मधिका for (मधिके)

(ख) ३. तद्युदलं for (तद्युदल)

(च) ६. परिधो for (परिधौ)

२३. (घ) १. षड्राशून्ये (च) for (षड्राश्यूने)

२. फल (च) for (बल)

(ग) ३. षड्राशधिके (क) षड्रास्यधिके (ख) षड्राश्याधिके for (षड्राश्यधिके)

२४. (क) १. तत्तिथ्यन्तः (ख) तत्तिथ्यन्तं for (तत्तिथ्यन्त)

प्राक् पश्चाद्वा याभिर्घ[4]टिकाभिर्दिनदलान्नतः[3] सूर्यः ।
तिथ्यंते तद्र[1]हिते त्रि[2]शत् [5]घटिकावशेषाभिः ॥ २५ ॥
विपरीतमर्धरात्राच्चन्द्र[2]ग्रहणे शशी रविग्रहणे ।
सूर्योयतस्[1]ततस्ताभिरेव[3] घटिकाभिरिन्दुरपि ॥ २६ ॥
दिनदल[1] परिधि स्फुट तिथिनतकेन्द्रज्या[2]वधो गुणोर्केन्दोः[3] ।
इंदू[4] धृति धृतिभि १९१ नवनववेदै[8] ४९९ व्या[7]सार्द्धकृतिर्भक्तः[5] ॥ २७ ॥
[6] १०६९२९००

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२५. (घ) १. तद्रह्विव for (ग) (तद्रहिते) (ग) तद्रहितस्त्रिशद् for (तद्रहिते त्रिशत्)(क) तद्रहितं for (तद्रहिते)
२. श्र्यंशद् (क) त्रिदशत for (त्रिशत्)
(ग) ३. नतसूर्यः for (नतः सूर्यः)
(ख) ४. घटिकाभि for (र्घटिकाभि)
५. त्रिंशदधिकावशेषाभिः for (त्रिंशत्घटिकावशेषाभिः)
(च) ३. द्दिनदलान्नत् सूर्यः for (दिनदलान्तत: सूर्यः)
२. त्रिशद् for (त्रिशत्)
२६. (घ) १. यतस्वषः for (यतस्ततस्)
२. चन्द्रग्रहणे (क) चन्द्रग्रहादिनिग्रहाणः for (चन्द्रग्रहणे)
३. रेवमथ for (रेव)
(च) २. चन्द्रग्रहणो for (चन्द्रग्रहणे)
२७. (घ) १. दज for (दल)
२. व्या for (ज्या) (क) ज्यावाधो for (ज्यावधो)
३. कैंन्द्वोः (ग) (ख) कैंन्द्रो for (कैंन्दोः)
४. इंद्वतिघृतिभि (ग) (क) इंदुविधृतिभि for (इंदूधृतिधृतिभि)
५. भक्तः for (र्भक्तः) (ग) (ख) कृतिभक्ति for (कृतिर्भक्तः)
६. १०६९ ॥ २९०० for (१०६९२९००)
(ग) ७. व्यासार्द्धकृति (क) व्यासार्द्धकृते for (व्यासार्द्धकृति)
वि० रेखाङ्कित दोनों संख्याएं "वेदै" के पश्चात् एक स्थान पर हैं। (१९१, ४९९)
(क) ३. गुणौर्कस्तः for (गुणोर्केन्दोः)
८. नंवनववेदै (च) for (नवनववेदै)
वि० संख्याएं मूल में लुप्त हैं।
(च) ३. कैंद्वोः for (कैंन्दोः) ५. भक्तः for (र्भक्तः)

फल[4]विकला वा [5]सूर्ये प्रागृ[6]णमसकृन्नते धनं पश्चात् ।
[7]केन्द्रफलमृणं [3]चन्द्रेऽन्यथा [1]धनं [2]चेहृणं स्पष्टौ ॥ २८ ॥
[5]अर्कफलभुक्तिघाता[1]द्भगणकलाप्तं [2]भुजांतरं रविवत् ।
स्फुटभुक्तिरतीतैष्य [4]ग्रहान्तरं वर्तमाने[3]ऽह्नि ॥ २९ ॥
क्षयधनहानि[1]धनानि प्राक् पश्चादन्यथा खेरिंदोः ।
प्राग्वत्पश्चा[3]त्स्वगतौ धनक्षयक्षयधनानि [2]प्राक् ॥३०॥
ब्रह्मोक्तमध्यरविशशितदुच्चतत्परिधिभिः [4]स्फुटीकरणम् ।
[1]कृत्वैनं स्पष्ट[2]तिथिर्दू[3]रभ्रष्टान्य[5]तंत्रोक्तैः ॥ ३१ ॥

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२८. (ग) १. धननं for (धनं)
२. चेहणं (क) मे ऋणं (ख) चेहणं for (चेहृणं)
(क) ३. चा प्रात्यपा for (चन्द्रेऽन्यथा)
(ख) ४. विकल for (विकला)
५. सूर्यो for (सूर्ये)
६. मासत्कृते for (मसकृन्नते)
७. धृतिभिर्नवनववेदौ for (केन्द्रफलमृणं)
(च) २. चेहणं for (चेहृणं)
२९. (घ) १. भरणे for (भगण)
२. +२१६०+(च)+२१६००+
(क) ३. ह्निः for (ह्नि)
(ख) ४. रतीतैष्यद् for (रतीतैष्य)
३. ऽहनि for (ऽह्नि)
(च) ५. अर्क्क for (अर्क)
४. रतीतैष्टचद्ग्रहांतरं for (रतीतैष्य ग्रहान्तरं)
३. ह्निः for (ऽह्नि)
३०. (क) १. 'धनानि' पद लुप्त है ।
२. प्राग्वत् for (प्राक्)
(ख) ३. +च+
३१. (घ) १. कृत्वैवं (ग) (क) (च) for (कृत्वैनं)
२. स्पष्टतिथे for (स्पष्टतिथि)
३. च for (भ्र)
(क) ४. स्फुटाकरणम् for (स्फुटीकरणम्)
५. कृत्रोक्तो for (तंत्रोक्तैः)

स्वदिनार्द्धं परिधिभुजफलचापं मध्यार्कचन्द्रयोः कृत्वा ।
पूर्ववदन्यत्स्पष्टं संव्यवहारार्थमेवं वा ॥ ३२ ॥
आर्यभटस्याज्ञानान्मध्यममन्दोच्चशीघ्रपरिधिना ।
न स्पष्टा भौमाद्याः स्पष्टा ब्रह्मोक्तमध्याद्यैः ॥ ३३ ॥
मंदोच्चनीचवृत्तस्य परिधिभागाः सितस्य विषमांते ।
नव ९ युग्मांते रुद्राः ११ शीघ्रौ जान्तेऽग्निरसयमलाः ॥ २६३ ॥३४॥
युग्मांतेष्टशरयमाः २५८ मंदफलात्मध्यमः स्फुटो मध्यः ।
शीघ्रफलात्स्पष्टो सकृदेवं स्वफलैर्ज्ञगुरुसौराः ॥ ३५ ॥

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३२. (घ) १. स्पष्टो (ग) स्पष्टौ (क) स्पष्टौ for (स्पष्टं)
(च) २. मध्यार्क्क for (मध्यार्क)

३३. (घ) १. परिधीनाम् (ग) (क) (च) for (परिधिना)
२. त for (न)
३. भौमाद्या for (भौमाद्याः)
(क) ४. स्पष्ट for (स्पष्टा)
(च) २. ते for (न) ३ भौमाद्या for (भौमाद्याः)
५. क्रमसंख्या लुप्त

३४. (घ) १. यमलाः (च) for (यमलाः)
२. ३४।२६३ for (२६३।३४) (क) संख्या लुप्त है।
(क) ३. शीघ्रो (च) for (शीघ्रौ)
(ख) यह श्लोक यहां ३० वें श्लोक के पश्चात् है। यद्यपि इस प्रति में श्लोक संख्या नहीं दी गई है।
(च) ४. विसर्गलुप्त ५. अवग्रहचिह्न लुप्त

३५. (घ) १. फलान् (ग) (क) (ख) मंदफला for (मंदफलात्)
(ग) २. मध्यम for (मध्यमः)
(क) ३. सौरः for (सौराः)
(ख) ४. युग्मांतिष्ठ for (युग्मांतेष्ट)
५. शरयमा for (शरयमाः)
(च) १. फलान् for (फलात्)

बुधमंदपरिधिभागावसुरामाः ३८ सुरगुरोस्त्रयस्त्रिंशत् ।
रविजस्यशून्यरामा ३० सशीघ्रपरिधिद्विगुणचन्द्राः ॥ ३६ ॥
देवगुरोरष्टरसा ६८ भास्कर पुत्रस्य शरगुणाः ३५ स्पष्टाः ।
कुजशीघ्रकेन्द्रपदगत ये अल्पज्याभिभागोनैः ॥ ३७ ॥

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३६. (घ) १. बुमंदपरिधि for (बुधमंदपरिधि)

२. +३३+(ग) (च)

३. ज्ञ (ग) (क) (ख) (च) for (स)

४. द्विगुण (ग) for (द्विगुण)

५. +१३२+(ग) (च)

(ग) ६. रामा for (रामाः)

(क) वि० मूल में अंकित संख्याएं यहां लुप्त हैं ।

(ख) ७. रंशा for (भागा)

८. त्रयस्त्रिशत् for (त्रयस्त्रिंशत्)

९. चन्द्रा for (चन्द्राः)

(च) १०. रामाः for (रामा)

३७. (घ) १. रस्य (क) रस for (रसा)

२. शरगुणा स्पष्टाः । ३५ for (शरगुणाः ३५ स्पष्टाः)

३. याल्पज्या (ग) (क) for (अल्पज्या)

४. त्रि (ग) (क) (च) for (त्रि)

५. नौः for (नैः)

(च) २. शरगुणस्पष्टाः ३५ for (शरगुणाः ३५ स्पष्टाः)
३. याल्पद्या for (अल्पज्या)

सप्तभिरंशैर्गुणिता[1] ६।४०[6] दिवर्द्धं[7] राशिज्यया हृताप्तांशैः[8] ।
२३१[2]
अधिकोनकुजमंदो[3] मृगकर्कादौ[9] स्फुटौ[4] भवतीति[5] ॥ ३८ ॥
तत्स्फुट[8]परिधिः[9] खनगाः ७०[1] शीघ्रस्फुटपरिधिराप्त[6]भागोनाः[4] ।
वेद[7]जिनांस्त्रिशोनाः[5] २४३।३०[2] स्फुटीकरणं[3] कुजस्यैवम् ॥ ३९ ॥

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३८. (घ) १. र्गुणिताः (च) for (र्गुणिता)
२. २३१२ (ग) (च) for (२३१)
३. नः (ग) (क) (च) for (न)
४. स्फुटो (ग) (क) (ख) (च) for (स्फुटौ)
५. भवति (ग) (क) भवंति (ख) भवति (च) for (भवतीति)

(ग) ६. यहाँ यह संख्या नहीं है (च) '४०' संख्या लुप्त

(क) ७. दिवार्द्धं for (दिवर्द्धं)
वि० मूल में दी गई संख्याएं लुप्त हैं ।

(ख) ८. हतासाशः for (हृताप्तांशैं)
९. ष्टगकवचादौ for (मृगकर्कादौं)

(च) ९. मृगकर्क्कादौं for (मृगकर्कादौं)

३९. (घ) १. ७०४० (च) for (७०)
२. २४३।४० (ग) (च) for (२४३।३०)
३. स्पटीकरणं (ग) स्पष्टीकरणं (ख) for (स्फुटीकरणं)

(ग) ४. राप्तभागोना for (राप्तभागोनाः)
५. स्त्रिशोनाः (ख) स्त्रांशोना for (स्त्रिशोनाः)

(क) ६. भागाः स्पष्टाः । (कुजशीघ्रस्फुट परिधिभागाभवंति)
७. दूसरी पंक्ति—के ते वेदस्त्रंशोना एते $\frac{२४३}{५०}$ परं आप्तं भागोनाः ।।
वि० ऐसा प्रतीत होता है कि लिपिकार मूल श्लोक लिखना भूल गया ।
केवल टीका उपलब्ध है ।

(ख) ६. राप्तो ना for (राप्तभागोनाः)

(च) ८. तेत्सुट् for (तत्स्फुट) ९ परिधिः for (परिधि)
५. स्त्र्यंशोनाः for (स्त्रिशोनाः)

मन्दफलं मध्येऽर्द्धं तच्छीघ्रफल च मध्यमे सकले।
मध्ये सकृत् क्षितिसुतः स्पष्टो भुक्ति स्फुटाग्रहवत् ॥ ४० ॥
ग्रहकेन्द्रभुक्तिज्याकरगुणिताद्यजीवया भक्ता २१४।
लब्धं स्फुट परिधिगुणं भगणांशहृतं कलाभिस्तु ॥ ४१ ॥

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४०. (घ) १. फलं (ग) (क) (ख) फलस्य for (फल)

२. सकलो (ख) (च) for (सकले)

३. मध्येऽसकृत् (क) मध्यशकृत for (मध्येसकृत्)

४. भुक्तिः (ग) (च) for (भुक्ति)

६. क्षितिसुते (ख) for (क्षितिसुतः)

७ स्फुटौ for (स्फुटा)

(ख) ८. र्धा (च) र्द्ध for (ऽर्द्ध)

(च) ९. तत्शीघ्र for (तच्छीघ्र)

४१. (घ) १. ग्रहमंदकेन्द्र (ग) (क) ग्रहमंद्रकेंद्रा (ख) ग्रहमंदकेन्द्र for (ग्रहकेन्द्र)

२. ज्यतिर (ग) ज्यांतर (क) ज्यतिर (ख) ज्यातर for (ज्याकर)

३. फलकबाभिः। (ग) (क) फलकलाभिः for (कलाभिस्तु)

(ग) ४. द्युजीवया (क) (ख) गुणिताद्या for (द्यजीवया)

(ख) ५. भक्ताः for (भक्ता)

६. स्फुटि for (स्फुट)

३. फलकलाभि for (कलाभिस्तु)

(च) १. ग्रहमंदकेंद्र for (ग्रहकेन्द्र)

२. ज्यांतर for (ज्याकर)

३. फलकबभिः for (कलाभिस्तु)

मृगकर्काद्यादूनाधिका[1] स्वमध्यमगतिः[6] स्फुटार्केंदोः[2] ।
शीघ्रगति[8]मंदफल[7][9]स्फुटभुत्तच्युनां[4] कुजादिना[5] ॥ ४२ ॥
शीघ्रफलं[1] भोग्यजीवागुणिता[2] माघजीवया[8] विभजेत्[3] ।
फलगुणितं व्यासार्द्धं[6] विभाजयेत्[5] शीघ्रकरणेन[4] ॥ ४३ ॥

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४२. (घ) १. मृगकर्व्यादावूना (ग) (क) मृगकर्काद्यवूनाधिका for (मृगकर्काद्यादूनाधिका)

२. स्फुटार्केंद्वोः (ग) (क) स्फुटार्केंदोः for (स्फुटार्केन्दोः)

३. शीघ्रगतिं (क) शीघ्रगतिः for (शीघ्रगति)

४. भक्तूनां (ग) भुक्तच्यूनां (क) भुत्तच्यूनां (ख) for (भुत्तच्युनां)

५. कुजादीनाम् । (ग) (क) (ख) कुजादीनाम् for (कुजादिना)

(ग) ६. स्वमध्या for (स्वमध्यम)

७. मंदफल (ख) मदे for (मंदफल)

(ख) इस श्लोक का पूर्वार्ध लुप्त है—

८. शीघ्रगतिः for (शीघ्रगति)

९. 'फल' पद लुप्त है ।

(च) २. स्फुटार्क्केंद्वोः for (स्फुटार्केंदाः)

४. भुत्तच्यूनां for (भुत्तच्युनां)

५. कुजादीनां for (कुजादिना)

४३. (घ) १. शीघ्रफल (ग) (क) (ख) शीघ्रफल (च) for (शीघ्रफलं)

२. शृंगुणिता (ग) संगुणिता (क) संगुणिता (ख) for (गुणिता)

३. भजेत् for (विभजेत्)

(ग) ४. च्छीघ्र (च) for (त् शीघ्र)

५. विभजयेत् (ख) विभाजये (च) for (विभाजयेत्)

(ख) ६. व्यासार्ध्यं for (व्यासार्द्धं)

७. शीघ्रकरणेना for (शीघ्रकरणेन)

(च) २. शृंगुणिता for (गुणिता) ८. माद्य for (माघ)

लब्धोनाशीघ्रगति[1]स्फुटभुक्तिर्लब्ध[2]मधिकं चेत् ।
शीघ्रगतेः शीघ्रगतिः[3] लब्धा[4] संशोध्य[5] वक्रगतिः[6] ॥ ४४ ॥
देयमसुताय नेदं[5] शपथैरपि दत्तसुकृतनाशाद्यैः[3] ।
यात्रा[4]विवाहजातक[1] फलस्फुटत्वं यतः स्पष्टैः[2] ॥ ४५ ॥
मेषादितः प्रवृत्तानार्यभटस्य स्फुटाः[1] युगस्यादौ ।
श्रीषेणस्य कुजाद्याः सूर्याद्य[2]विष्णुचन्द्रस्य[3] ॥ ४६ ॥
दूरभ्रष्टाः[3] स्पष्टा[2] श्रीषेणार्य[4]भटविष्णुचन्द्रेषु[5] ।
यस्मात् कुजादयस्तेषु न विदुषामादरस्तस्मात् ॥ ४७ ॥

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४४. (घ) १. शीघ्रगतिः (ग) (क) गति (ख) शीघ्रगतिः (च) for (शीघ्रगति)
२. भवति लब्ध (ग) भवति लब्ध (ख) भवनि लब्ध for (र्लब्ध)
३. शीघ्रगति (ग) (क) (ख) शीघ्रगतं for (शीघ्रगतिः)
(क) ४. लब्वात् for (लब्धा)
(ख) ५. संसोध्य for (संशोध्य)
६. वक्तगतिः for (वक्रगतिः)
(च) २. +भवति+
३. शीघ्रगति for (शीघ्रगतिः)
४५. (घ) १. जातकं (ख) जातव for (जातक)
२. स्पष्टै for (स्पष्टैः)
(क) ३. नाशोचैः (ख) नशाद्यैः for (नाशाद्यैः)
४. यत्र for (यात्रा)
(च) ५. नेदशपंथै for (नेदं शपथै)
४६. (घ) १. स्फुटा (ग) (क) (ख) स्फुटा (च) for (स्फुटाः)
२. ज्या (ग) द्या (ख) द्याः for (द्य)
(ख) ३. विष्नचंद्रस्य for (विष्णुचन्द्रस्य)
(च) २. सूर्याद्या for (सूर्याद्य)
४७. (घ) १. (चट) for (भट)
(ग) २. स्पष्टाः (ख) for (स्पष्टा)
(ख) ३. दूरभ्यष्टः for (दूरभ्रष्टाः)
४. 'आर्य' लुप्त है
५. चन्देषु for (चन्द्रेषु)

अग्न्यष्टभिरिषुमनुभिः शरसूर्यैरिषु रसेंदुभिस्त्रिभवैः ।
शीघ्रान्त्यकेन्द्रभागैर्भौमादीनां भवति वक्रम् ॥ ४८ ॥
वक्रांशकैस्तदूनैः ३६० रनुवक्रं तदधिकोन भागकलाः ।
मंदफलस्फुट भुक्त्यून शीघ्रभुक्त्याहृता दिवसाः ॥ ४६ ॥
शीघ्रस्फुटाग्रहोना छेषे मध्यस्फुटांतरार्द्धं वा ।
अधिकेधनमृणमूने स्फुटग्रहा मध्यमे कृत्वा ॥ ५० ॥

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४८. (ग) १. अग्निष्टिभि (क) अग्न्यष्टिभि (च) for (अग्न्यष्टभि)
२. रिषुमुनिभिः for (रिषुमनुभिः)
३. +भौ० व० कें० ॥ ५ । १३ । ० ॥ बु० व० कें० ॥ ४ । २५ । ० । ० ॥
बृ० व० कें० ॥ ४ । ५ । ० । ० ॥ शु० व० कें० ॥ ५ । १५ । ० । ० ॥
श० व० कें० ॥ ३ । २३ । ० । ० ॥+

(ख) १. अग्न्याष्टिभि for (अग्न्यष्टभि)
४. रसेद्रुभि for (रसेंदुभि)
५. क्रर्म for (वक्रम्)

(च) २. रिषुमनुभि for (रिषुमनुभिः)

४६. (क) १. चक्रांशकै for (वक्रांशकैं)

(ख) २. वक्तं for (वक्रम्)
३. भुक्त्यान for (भुक्त्यून)

५०. (घ) १. स्फुट (ग) (क) for (स्फुटा)
२. ग्रहान् (ग) (क) ग्रहान् for (ग्रहा)

(क) ३. शीघ्रात् (ख) for (शीघ्र)
४. ग्रहोनात् for (ग्रहोना)

(ख) ५. च्छेषे for (छेषे)
६. स्फुटार्धं वा for (स्फुटांतरार्द्धं वा)
७. नष्टणमूने for (नमृणमूने)

(च) २. स्फुटग्रहान् for (स्फुटग्रहा)
८. यहां क्रम संख्या भूल से "१५०" अंकित है।
वि० यहां पर जो सारणी दी गई है। वह मूल पाठ में ५२ वें श्लोक में दी गई है।

राशिषु चतुर्षु वक्रं[1] षट्[6]स्वति वक्रमनुवक्रमष्टासु । ४[2] । ५ । ८
अप्राप्ता[3] प्रीतीतकाला भुक्त्या[8] सैवोद्[4]धृता दिवसाः[5] ॥ ५१ ॥
अष्टयमैः[4] कृतचन्द्रै[9]र्मुनी[10]न्दुभिर्भौम[5]जीव[8] रविजानाम्[6] ।
उदय[7]प्रागस्तमयस्तदून[11]वक्रांशकं[1] पंचात्[2] ॥ ५२ ॥

५	४	४	४	३
१३	२५	५	१५	२३
०	०	०	०	०
०	०	०	०	०

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५१. (घ) १. वंक्रं for (वक्रं)
२. ४ । ६ । ८ (ग) (च) for (४ । ५ । ८)
३. अप्राप्तातीतकला (ग) अप्राप्ताताऽकला (ख) अप्राप्तातीतकाला for (अप्राप्ताप्रीतीतकाला)
४. स्यैवौद्धृता (ग) (क) (ख) for (सैवोद्धृता)
(ग) ५. दिवसा (ख) (च) for (दिवसाः)
(क) ३. अप्राप्ताऽतीतकला for (अप्राप्ताप्रीतीतकाला)
(ख) ६. षटत्वति for (षट्स्वति)
७. 'नु' पद लुप्त है ।
८. भक्त्या for (भुक्त्या)
(च) ६. 'षट्स्व' लुप्त ० अप्राप्तातीतकला for (अप्राप्ताप्रीतीतकाला)

५२. (घ) १. वक्रांशकैः (ग) (क) चक्रांशकैः (ख) वक्तांशकैः for (वक्रांशकै)
२. पश्चात् (ग) (क) (ख) पश्चात् for (पंचात्)
३. यहां यह तालिका ५०वें श्लोक के साथ है (ख) लुप्त है
(ग) ४. अष्टमैः (ख) अष्टयमै for (अष्टयमैः)
५. भौमजा (क) भौम for (भौम)
६. +२८ । १४ । १७ +
७. उदयः (ख) for (उदय)
३. यहां यह तालिका नहीं दी हुई है (क)
(क) ८. रविजानाम् for (रविजानाम्)
(ख) ९. कृतचन्द्रैः for (कृतचन्द्रै)
१०. मुनिदुभौम for (मुनीन्दुभिर्भौम)
११. तादून for (तदून)
(च) १. वक्रांशकैः for (वक्रांशकै) २ पश्चात् for (पंचात्)

खशरैर्जिनैर्ज्ञसितयोः २८ । १४ । १७ । ५० । २४ रिषुतिथिभिर्मुनिनगें-
दुभिः पश्चात् । १५५, ११७७
उदयास्तमयो व्यस्तौ मंडलभागैस्तदूनैः प्राक् ॥ ५३ ॥
स्पष्टाद्युराभिदलयोरव्यूदयान्तमये यौ रविचरार्द्धात् ।
एष्यत्यधिके तीतादवक्रिते हीनौ ॥ ५४ ॥

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५३. (घ) १ १५५११७७ (ग) १५५ । १७७ for (१५५, ११७७)
२. न्यस्तौ for (व्यस्तौ)
३. मंडभागैः for (मंडलभागै)
४. प्राकः for (प्राक्)

(ग) ५. ज्ञंसितयोः । ५० । २४ ॥ (ख) ज्ञासितयो (च) for (ज्ञंसितयोः)
६. उदयास्तमयौ (क) (ख)
७. +३६०+

(क) वि० संख्याएँ मूल में नहीं दी गई हैं।

(ख) ८. स्वशरै जिनै for (खशरैर्जिनै)

५४. (घ) १. त्रि for (भि) (ग) (क) (ख) रात्रि for (राभि)
२. रव्युदयोस्तमययो (ग) रव्युदयास्तमययो (ख) for (रव्यूदयान्तमये यौ)
३. क्रितो (ग) (क) (च) for (क्रिते)
४. हीने (ग) (क) for (हीनौ)

(क) २. रव्युदयास्तमययो for (रव्यूदयान्तमये यौ)
५. +वक्रितो+

(ख) ६. रविचराघात् for (रविचरार्द्धात्)
७. एह्यात्यधिके for (एष्यत्यधिके)
८. तीतादेवक्रितो for (तीतादवक्रिते)

(च) २. रव्युदयास्तमये for (रव्यूदयान्तमये)

जिनभागज्या[9] गुणिता[1] सूर्याद्या[7] व्यासदलहृता[2]लब्धम्[2] । ३२७०[3]
इष्टापक्रमजीवा[4] विषुवद्दुग्[5] दक्षिणा[8] सवितुः[6] ॥ ५५ ॥
इष्टापक्रम[6]वर्गमिज्या[1]वर्गाद्विशोध्य[2] १०६६१६००[5] शेषपदम् ।
विषुवदुदग्[7] दक्षिणतः[3] स्वाहोरात्र्यार्द्ध[4] विष्कंभः[8] ॥ ५६ ॥

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५५. (घ) १. +१३२६+(च)
२. +३२७०+(ग) (च)
३. यह संख्या यहाँ पर 'हृता' के पश्चात् है ।
४. इष्टा for (इष्टा)
५. विषुवदुदिग्दक्षिणा (ग) विषुवदुदिग्दक्षिणे for (विषुवद्दुग्दक्षिणा)
६. सवितु (ख) सवितु (च) for (सवितुः)

(ग) ७. +१३२६+सूर्यज्या (क) सूर्याज्या (ख) सूर्यज्य for (सूर्याद्या)
(क) ८. दक्षिणे (ख) दक्षिण for (दक्षिणा)
(ख) ९. जिनभागाज्या for (जिनभागज्या)
(च) ५. विषुवदुदग्दक्षिणा for (विषुवद्दुग्दक्षिणा)

५६. (घ) १. वर्ग त्रिज्या (ग) (क) (ख) वर्गत्रिज्या for (वर्गमिज्या)
२. वर्ग्गाद्विशोध्य (ख) वर्गाद्विशेषपदम् for (वर्गाद्विशोध्य)
३. दक्षणतः (च) for (दक्षिणतः)
४. स्वाहोरार्द्ध (ग) स्वाहोरात्रार्द्ध (क) स्वाहोरात्रार्द्ध for (स्वाहोरात्र्यार्द्ध)

(ग) ५. +१०६६२६००+

(ख) ६. इष्टमपक्रम for (इष्टापक्रम)
७. 'ग्' लुप्त
४. स्वाहोरात्रार्घ for (स्वाहोरात्र्यार्द्ध)
८. विष्कभ्र: for (विष्कंभः)

(च) १. वर्गं त्रिज्या for (वर्गमिज्या)
४. स्वाहोरार्द्धं for (स्वाहोरात्र्यार्घ)

क्रान्तिज्या विषुवच्छायया[1] गुणा[6] द्वादशो धृता[2] क्षितिजा ।
स्वाहोरात्रेऽनष्टा[3] व्यासार्धेनाहता[5] भक्ता[4] ॥ ५७ ॥
स्वाहोरात्रार्द्धेन क्षयवृद्धिज्याधनुश्चरप्राणाः[4] ।
षट्कोधृता[1] विनाड्यो[3][5] विनाडिका[6] नाडिका षष्ट्या[2] ॥ ५८ ॥
चरदल[3]घटिका गुणिता भुक्तिः[6] षष्ट्याहता[7] कलाद्याप्तम्[1] ।
ऋण[4]मुदयेऽस्तमये[5] धनमुत्तर[8]गोलेऽन्यथा[2] याम्ये ॥ ५९ ॥

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५७. (घ) १. त्सायाया (ग) छायया (ख) विषुचछाया for (विषुवच्छायया)
२. द्धृता (ग) (ख) हृता for (धृता)
३. स्वाहोरात्रेनष्टा (ख) (क) स्वाहारात्रेनष्टा for (स्वाहोरात्रेऽनष्टा)
४. भक्ताः (ग) for (भक्ता)
(ग) ५. व्यार्द्धेनाहता (ख) सार्धेन हृता for (व्यासार्धेनाहता)
(ख) ६. गुण for (गुणा)
(च) २. द्धृता for (धृता) ३. स्वाहोरात्र for (स्वाहोरात्रे)
५. व्यासार्द्धे for (व्यासार्धे) ४. भक्ताः for (भक्ता)

५८. (घ) १. द्धृता (ग्र) (क) (ख) (च) for (धृता)
२. षष्ट्याः (ख) षष्टा for (षष्ट्या)
(ग) ३. विड्यो for (विनाड्यो)
(ख) ४. श्चर for (चर)
५. + भवंति नाड्यो +
६. 'डका' लुप्त है
(च) २. षष्ट्याः for (षष्ट्या)

५९. (घ) १. घाप्तम् (ग) घातम् (ख) द्यप्तम् for (द्याप्तम्)
२. गोलेन्यथा (ग) (च) for (गोलेऽन्यथा)
(ग) ३. पल for (दल)
४. ऋण for (ऋण)
५. ऽस्तसमये for (ऽस्तमये)
(क) ६. भुक्ति for (भुक्तिः)
७. हृता (च) for (हृता)
८. मुत्तरं for (मुत्तर) (ख) धनुत्तरगोलेन्यथा for (धनमुत्तरगोलेऽन्यथा)
(च) ५. अवग्रहचिह्न लुप्त

दिनरात्रिमानघटिकाश्चरार्द्धनाडीभि[1]रुत्तरगोले ।
पंचदश १५[2] युक्त[4]हीना याम्ये[5] हीना[6]धिका द्विगुणाः[3] ॥ ६० ॥
भान्य[5]श्विन्यादीनि ग्रहलिप्ता[6] खखवसु[1] ८००[2] द्धृताल्लब्धम् ।
भुक्ति[5]हृते गतगम्ये दिवसाः[3] दिवसा[3] षष्ट्याहृते[8] घटिका ॥ ६१ ।
अर्कोन[8] चन्द्र लिप्ताः[1] खयम[6] स्वर[7] ७२०[4] भाजिता फलं तिथयः[5] ।
गतगम्ये षष्टिगुणे[1] भुक्त्यन्तर भाजिते घटिका[6] ॥ ६२ ॥

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६०. (ग) १. रुत्तरे (क) (ख) कत्तरे for (रुत्तर)
२. यह संख्या लुप्त है
३. यहां (:) लुप्त हैं (क)
(क) ४. युक्ति for (युक्त)
५. ६ 'याम्ये हीना' पद लुप्त हैं। (ख)
(च) १. रुत्तरे for (रुत्तर)

६१. (घ) १. खखवसूद्धृता (क) (ख) खखावस्तूद्धृता for (खखवसु ८०० द्धृता)
२. यह '८००' संख्या यहां न होकर 'लब्धम्' के पश्चात् है (ग)
३. 'दिवसा' इस प्रति में विद्यमान नहीं (क) (ख) विवसाः for (दिवसा)
(ग) ४. यह पद यहां लुप्त है (ख)
(क) ५. भान्यस्विन्यादीनि (ख) भन्याश्विन्यादीनि for (भान्यश्वन्यादीनि)
६. लिप्ताः for (लिप्ता)
(ख) ७. भुक्तिहृते for (भुक्तिहृते)
८. गुणे च्च घटिका for (षष्ट्याहते घटिका)
(च) १. वसूद्धृता for (वसुद्धृता)

६२. (घ) १. लिप्ता (क) for (लिप्ताः)
२. गुण (ग) for (गुणे)
३. घटिकाः (च) for (घटिका)
(ग) ४. यह संख्या 'भाजिता' और 'फलं' के बीच में है
५. तिथियः (ख) तिथ्ययः for (तिथयः)
(क) ६. खयमा for (खयम)
(ख) ७. खर for (स्वर)
(च) ८. अर्क्को for (अर्को) ४. संख्या लुप्त

रविचन्द्रयोगलिप्ताः खयमस्वरभाजिताः फलं योगः[१] ।।
गतगम्ये षष्टिगुणे भुक्तिसमासाद्धृते[२] नाड्यः ।। ६३ ।।
राश्यंश[४]कला विकलाः[५] स्फुटमासांते[३] लिप्तिका[६] विकला[१] ।
पक्षांते[८] तिथ्यंते समा रवीन्दोः[२] कला विकलाः[७] ।। ६४ ।।

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६३. (घ) वि० यह श्लोक इस प्रति में उपलब्ध नहीं। न इस संख्या का कोई दूसरा श्लोक ही। ऐसा प्रतीत होता है कि लिपिकार द्वारा यह श्लोक लिखने से रह गया।

(ग) यह श्लोक इस प्रति में भी उपलब्ध नहीं है।

(क) इस प्रति में उपलब्ध नहीं।

(च) १. योगा: for (योग:) २. समासाधृते for (समासाद्धृते)
वि० यह श्लोक इस प्रति में १५A पृष्ठ पर ऊपर की ओर किसी अन्य हाथ से लिखित है।

६४. (घ) १. विकला: (ग) (क) (च) (विकला)
२. रवीन्द्वोः (ग) (क) रवीस्ताः (ख) रवीन्द्वोः (च) for (रवीन्दोः)

(ग) ३. मासांतेश (घ) (क) (ख) मासांतेशा for (मासांते)
वि० इसकी श्लोक संख्या ६३ है।

(क) ४. राश्यंश (ख) राशांश for (राश्यंश)

५. विकला for (विकलाः)

६. लिप्तिको for (लिप्तिका)

७. विवरलाश्चा for (विकलाः)
इसकी श्लोक संख्या ६३ है।

(ख) ८. पक्षातो for (पक्षांते)

(च) ३. मासांतेश for (मासांते)

कृष्णचतुर्दश्यन्ते[१] शकुनि[४] पर्वणि चतुष्पद[२]प्रथमे ।
तिथ्यर्द्धंते[३] नागं[५] किंस्तुघ्नं[७] प्रतिपदाद्यर्द्धे[६] ।। ६५ ।।
व्यर्कदु[७] कला भक्ता:[३] खरस[४]गुणै: ३६० लब्ध[५]मूनमेकेन ।
चल[८]करणानि व[९]वादीन्यग[२] हृतशेषे तिथि[६]वदन्यत्[१] ।। ६६[१०] ।।

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६५. (घ) यह श्लोक इस प्रति में उपलब्ध नहीं है ।

(ग) १. र्दश्यंते शशकुनि: for (र्दश्यन्ते शकुनि) (ख) चतुर्दशांते for (चतुर्दश्यन्ते)
२. चतुष्पदं (क) (ख) (च) for (चतुष्पद)
३. तिथ्यर्द्धेंत्येनागं (क) तिथ्यर्द्धेऽत्ये (ख) तिथ्यर्वेत्यनाग: for (तिथ्यर्द्धंते नागं)

(क) ४. शकुनि: (ख) for (शकुनि)
५. मार्गं for (नागं)

वि० इसकी श्लोक संख्या ६४ है ।

(ख) ७. किंस्तुघ्नप्रति for (किंस्तुघ्नं प्रति)

(च) ३. तिथ्यर्द्धेते for (तिथ्यर्द्धंते)

६६. (घ) १. वदन्यत: for (वदन्यत्)
इस श्लोक की क्रमसंख्या ६५ है। (ग) (क)

(ग) २. +७+(च)

(क) ३. भक्ता for (भक्ता:)
४. त्खर (स्व) स्वरस for (खरस)
५. लंब्ध (च) for (लब्ध)
६. तिथिन्यत् ।। ६६ ।। (ख) तिथि वदन्यात् for (तिथिवदन्यत्)

(ख) ७. व्यर्केंद्रकला for (व्यर्केंदुकला)
८. वल for (चल)
९. च for (व)

(च) १०. क्रमसंख्या ।। ६५ for (६६)

इह नोक्तानि बहुत्वात्[२] स्पष्टगते[३]रुत्तरे[५]भिधास्यामि[४] ।
संक्रांति[१]भतिथिकरण[६] व्यतिपाताद्यंत[७] गणितानि ।। ६७ ।।[८]
ज्या[५] परिधि[८] स्पष्टीकरण[६] दिनगतिचरार्द्ध[७] करणेषु[१] ।
स्फुटगतिरध्याय[२] सप्तषष्टिरार्या द्वितीयोऽयम्[३] ।। ६८ ।।
इति ब्रह्मगुप्ते[४] २योऽध्यायः ।।

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६७. (घ) १. थिमकरण for (भतिथिकरण)
वि० इसकी श्लोक संख्या ६६ है । (ग) (क)

(क) २. बहुत्वत् for (बहुत्वात्)
३. स्पष्टगंते for (स्पष्टगते)
४. ऽभिधास्यामि for (भिधास्यामि)
६. 'करण' पद लुप्त है ।
७. व्यतीपाताद्य for (व्यतिपाताद्यंत)

(च) ४. वधास्यामि for (भिधास्यामि)
८. ।। ६६ ।। for (।।६७।।)

६८. (घ) १. +भतिथि+ (ग) (ख)
२. गति रध्यायः (ग) (क) (ख) गत्यध्यायः for (गतिरध्याय)
३. द्वितीयोयम् (ग) (च) for (द्वितीयोऽयम्)
इसकी श्लोक संख्या ६७ है । (च)
४. 'इति'—से 'अध्यायः' तक यहां अंकित नहीं इस अधिकार में केवल ६७ श्लोक हैं । (क)

(ग) ५. या for (ज्या)
६. करणं (ख) करणा for (करण)
७. दिनमानचरार्द्ध (ख) दिनरात्रिचरार्द्ध for (दिनगतिचरार्द्ध)
४. 'इति श्रीब्रह्मसिद्धान्ते स्फुटिकर्णाधिकारो द्वितियः' यह नोट और ही लेखनी का है, काग़ज़ के ऊपर दिया गया है ।

(क) ८. परिधिः for (परिधि)

(च) १. +भतिथि २. रध्यायः for (रध्याय)
४. 'इति' से 'अध्यायः' तक अंकित नहीं है ।

पूर्वापरयोर्विद्धो[1] तुल्य छायाग्रयो दिगपराद्याः[2] ।
पूर्वान्यः[5] क्रान्तिवशात्तन्मध्यात्[4] शंकुतलमितरे[3] ॥ १ ॥
नृच्छायाग्रगजमत्स्य[1] द्वयमध्यगसूत्रयोर्युति[2]र्यत्र[4] ।
सोत्तरगोले याम्या[5] शंकुतला[3] दक्षिणे सौम्या ॥२॥
छायाग्रभ्र[6]मरेखा सूत्रद्युते[1]र्वृ[2]तपरिधिरग्रस्पृक् ।
मध्य[7]छायान्तरमुदगीतरं[3] वा[5] शंकुमण्डलयोः[4] ॥ ३ ॥

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१. (घ) १. विद्ध (ग) विंदू (क) बिन्दु (ख) विन्दू for (विद्धो)
 २. हिगपराध: (ग) दिगपरार्धः (क) दिगपराधः for (दिगपराद्याः)
 (ग) ३. छंकुतलमितरे (क) (ख) for शंकुतलमितरे)
 (क) ४: तन्मध्या (ख) तन्मध्य for (तन्मध्यात्)
 (ख) २. दिग्पराद्यः for (दिगपराद्याः)
 ५. मूर्धन्याः for (पूर्वान्यः)
 (च) २. द्दिग for (दिग)

२. (घ) १. नृछायाग्रजमत्स्य (क) त्रिछायाग्रजमस्य (ख) त्रिछायाग्रजमत्स्य for (नृछाया-ग्रगजमत्स्य)
 (ग) १. त्रिछायाग्रजमछय for (नृछायाग्रगजमत्स्य)
 २. युति for (र्युति)
 ३. छंकुतला (क) कुंतला for (शकुंतला)
 (क) ४. यत्र for (र्यत्र)
 ५. याम्यात् for (याम्या)
 (क्षेप) क्षेपक नत्काले द्विवरं क्रान्त्यो लंबेन भाजितं गुणयेत् ।
 तत्कर्णेन छायायाः प्राचीलब्धां गुणैरयनैः ॥ २ ॥ इतिक्षेपः
 (ग) यह श्लोक इसी 'प्रति' में वह भी 'क्षेप' के नाम से उपलब्ध है ।
 (क) यह श्लोक इस प्रति में नहीं है ।
 (च) यह श्लोक इस प्रति में नहीं है ।

३. (घ) १. युते (ग) (क) युते (ख) (च) for (द्युते)
 २. वृंत्तस्पक् (ग) वृत्त (ख) वृत्त (च) for (वृंत)
 ३. सुदगितरं (ग) मुदगिरद्वा (क) मुदगितरथा for (मुदगीतरं)
 ४. मंडलयो (च) for (मंडलयोः)
 (क) ५. 'वा' पद लुप्त है । (ख) द्वा
 (ख) ६. 'भ्र' लुप्त है
 ७. मध्या for (मध्य)
 ३. मुद्गितर for (मुदगीतरं)

छायावृ[1]तेऽर्काग्रा कर्ण[5]गुणा व्यासदल हृता[4]र्काग्रा ।
विषु[2]वच्छाया याम्या तदंतरैक्यं भु[3]जस्याग्रे ॥ ४ ॥
शंकु[5]प्रा[7]च्य[1]परा या छाया भुजकृतिविशेषमू[2]लं नयत् ।
तत्प्रा[9]च्यपर[3]छाया भुजा[4]ग्रयोरन्[8]तरं को[6]टिः ॥ ५ ॥
दिग्[2]मध्ये छायाग्रं कृत्वा शंको[4]र्यथादिशं भ्रमणम् ।
दिग्[5]मध्यस्थित[3]शंकोः छायाग्रं भ्र[1]मति विपरी[6]तम् ॥ ६ ॥

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४. (घ) १. वृत्तेर्काग्रा (ग) (ख) वृत्ते र्काग्र for (वृत्तेऽर्काग्रा)
२. विषुवछायाम्या (ग) विषुवछायायाम्या for (विषुवच्छाया याम्या)
३. भुजोस्यार्ग्रे (ग) भुजोस्याग्रे (क) भुजोस्याग्रो for (भुजस्याग्रे)
(ग) ५. कार्णनुगा for (कर्णगुणा)
(क) २. विषुवछाया for (विषुवच्छाया)
(ख) ४. हृतार्काग्रा for (हृतार्काग्रा)
३. भुजोस्याग्रे for (भुजस्याग्रे)
(च) १. वृत्तेर्क्काग्रा for (वृत्तेऽर्काग्रा) ४. हृतार्क्काग्रा for (हृतार्काग्रा)
२. विषुवछा for (विषुवच्छाया) ३. भुजोस्याग्रे for (भुजस्याग्रे)

५. (घ) १. परयो (ग) परायाः (क) परायाः for (पराया)
२. 'न' इस प्रति में नहीं है। (ग) (क) (च)
४. भुजर्ग्रेयो for (भुजाग्रयो)
(ग) ५. शंकुः (ख) शकुः for (शंकु)
(क) ६. कौशि for (कोटिः)
(ख) ७. प्राच्या for (प्राच्य)
८. रन्तरे for (रन्तरं)
(च) ९. तत्प्राच्यां for (तत्प्राच्य) ४. भुजग्रयो for (भुजाग्रयो)

६. (घ) १. भ्रवति (क) for (भ्रमति)
(क) २. दिग्मध्य (ख) दिङ्मध्ये for (दिग्मध्ये)
३. शंकेश् (ख) शंको for (शंकोः)
(ख) ४. शांकोर्यचथादिशं for (शंकोर्यथादिशं)
५. दिङ्मध्ये for (दिग्मध्य)
(च) ३. शकोः for (शंकोः)
६. विपरितं for (विपरीतं)

शंकुर्लंबछायाक्षज्या तद्वर्गसंयुते मूलम् ।
विषुवत्कर्णछाया कर्णोत्यदा शंकुः ॥ ७ ॥
उन्नतजीवाकोटिः छाया दृग्ज्या भुजो नतज्या वा ।
कर्णछायावृत्तं व्यासार्द्धं द्वयमतोन्यत्र ॥ ८ ॥

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७. (घ) १. क्षय्या (ग) क्षज्य (ख) वज्या for (क्षज्या)
२. मूर्लम् (च) for (मूलम्)
३. विषुव तिथिषुव (ग) विषुवति विषुवति for (विषुवत्)
४. कर्णोन्यदा (ग) (क) कर्णोऽन्यदा for (कर्णोत्यदा)

(ग) ५. शंकुर्लम्बः (क) शंकुर्लंबश (ख) शंकुलंब for (शंकुर्लंब)
६. कर्णः छाया (क) कर्णश्छाया for (कर्णछाया)

(क) ७. +विषुवति+(च)

(ख) ७. +विषुवति+
४. कर्णोन्यदा for (कर्णोत्यदा)

(च) १. क्षय्या for (क्षज्या) ४. कर्णोन्यदा for (कर्णोत्यदा)

८. (घ) १. कोटिछाया for (कोटिः छाया) (ख) उत्ततजोवकोटि for (उन्नतजीवा-कोटिः)
२. यत्रः for (यत्र)

(ग) ३. द्रिक्ज्या (क) शध्या for (दृग्ज्या)
४. भुजानतज्यावा for (भुजोनतज्यावा) (ख) भुज्या for (भुजो)
५. कर्णः for (कर्ण)

(क) ६. वा (छ) यः for (छाया)
७. तस्या (ज्या) या for (तज्या वा)
८. वृत्तव्यवसार्द्ध for (वृत्तं व्यासार्द्धं)
९. द्वयासनोऽस्यत्रम् for (द्वयमतोन्यत्र)
इसकी श्लोक संख्या ६ है, संभवतः यह मूल है ।

(ख) १०. सार्द्ध for (सार्धं)

(च) १. कोटि for (कोटिः) ३. दृग्द्या for (दृग्ज्या)

शंकु छाया[७] कृत्योस्त्रिज्या कृतितत्समास[५] गुणहृतया[१] ।
मूलं[२] लम्बाक्षज्येस्[३]तदंशकास्[६]तद्धनुर्भागाः[४] ॥ ९ ॥
विषुवत्कर्णहृते[६] वा शंकु छायागते[३] पृथक् ।
त्रिज्ये[५] त्रिज्येतर जीवा[१] लंबाक्षांसो क्रमज्योना[२] ॥ १० ॥

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९. (घ) १. हृतयो (ग) हृतयोः (ख) हतयोः for (हृतया)

२. मूले (क) (ख) for (मूलं)

३. लंबाक्ष्यज्येतदंश (क) लबाक्षस्थे for (लंबाक्षज्येस्तदशं)

४. तर्द्धनुर्भागाः (क) सद्वक्रभागाः (ख) तद्धनुमागः for (तद्धनुर्भागाः)

(क) ५. नृत्यमासनस्य सूत्रयोः for (तत्समासगुणहृतया)

६. तदसंकाश (ख) तदशकास्व for (तदंशका)

इसकी श्लोक संख्या ८ है

(ख) ७. क्वाया for (छाया)

(च) ३. लम्बाक्ष्यजे for (लम्बाक्षजे) ६. तदंशका for (रतदंशका)

१०. (घ) १. जीवा वालंबाक्षांशो (क) (ख) जीवावलंबाक्षाशो for (जीवालंबाक्षांसो)

२. त्क्रमज्योना (क) कामावना (ख) कमज्योना for (क्रमज्योना)

३. छायाहृते (ग) (क) छायाहते (ख) हृते for (छायागते)

(ग) ४. लंबाक्षांशो for (लंबाक्षांसो)

(क) ५. त्रिद्येतर (ख) तिज्ये for (तिज्येतर) इसकी श्लोक संख्या ११ दी है। परन्तु यह भूल प्रतीत होती है क्योंकि इसकी टीका के अन्त में १० लिखा है।

(ख) ६. विषुत्वार्यहिते for (विषुवत्कर्णहृते)

(च) ३. छायाद्गते for (छायागते)

२. लंबांक्षांशोत्क्रमज्योना।

नवते ९० लम्बांशात्प्रोज्य ज्यावेतराक्षलम्बज्ये ।
शंकुछायागुणिते छाया द्वादशहृते वान्ये ॥ ११ ॥
लंबाक्षज्यावर्गं प्रोह्यज्या कृतेः पदं वान्याः ।
अन्यत्र सर्वदोन्नत जीवांशा नयनमेव ॥ १२ ॥
इष्टदिनार्द्धनतांश क्रान्त्यंशैक्यांतरं क्रियतुलादौ ।
अक्षांशा याम्यायां छायायामंतरमजादौ ॥ १३ ॥

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११. (घ) १. लंबाक्षांशात्प्रात्सज्या (ग) लंबाक्षांशान् (क) लंबाक्षांशान् (त्) for (लंबांशात् प्रोज्यज्या)
(ग) २. यह संख्या लुप्त है (क)
३. प्रोह्य ज्यवितराक्ष (क) प्रोह्यज्या (ख) प्राज्याज्यार्ध for (प्रोज्यज्यावेतराक्ष)
(क) ४. नवतै for (नवते)
(ख) १. लंबक्षाशान् for (लम्बांशात्)
५. लंबज्यो for (लंबज्ये)
(च) १. लंबाक्षांशात् for (लम्बांशात्)
१२. (घ) १. प्रोक्तज्याकृतेः (ग) प्राज्यत्रिज्योकृतेः (क) प्रोह्य त्रिज्या for (प्रोह्यज्याकृतेः)
२. वान्या (ग) (क) वान्यः for (वान्याः)
३. नतजीवांशा (ग) (क) (ख) नजीवांशा for (न्नतजीवांशा)
४. मेवम् (ग) (च) for (मेव)
(ग) ५. वर्ग्र (ख) वर्ग for (वर्गं)
(ख) १. प्रोज्या त्रिज्या for (प्रोह्यज्या)
४. नयनमवम् for (नयनमेव)
(च) १. प्रोज्य for (प्रोह्य)
२. वान्या for (वान्याः)
१३. (घ) १. दिनार्द्धन्नतांश (ख) दिनार्द्धनातांश for (दिनार्द्धनतांश)
(ग) २. क्रान्ति (क) क्रान्त्यां (ख) क्रान्त्यै for (क्रान्त्यं)
(ख) ३. शैक्यंतर for (शैक्यांतरं)
४. तुल्यादौ for (तुलादौ)
५. अक्षांश for (अक्षांशा)
६. षाम्यायां for (याम्यायां)
७. 'या' लुप्त है
(च) १. दिनार्द्धन्नतांश for (दिनार्द्धनतांश)

मेषवृषमिथुनजा[१] स्वाहोरात्र्यार्द्ध[२] चरदलप्राणान्[३] ।
प्राग्वत्कृत्वा स्वाधो[४] विशोध्य चरखंडकप्राणाः[५] ।। १४ ।।
मिथुनाहोरात्रार्द्धं[१] क्रियाहोरात्र[३]दल[५]हत[४] गुणितम् ।
तज्ज्याभि[६]राप्तं[२] चापान्तराणि[७] लंकोदयप्राणाः[८] ।। १५ ।।
ज्यावर्गात्तत्क्रान्तिज्या[५] वर्गोनात्तत्पदाहृता[१] त्रिज्या[२] ।
स्वाहोरात्रार्द्ध हताश्[३]चापांतराण्यथवा[४] ।। १६ ।।

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१४. (घ) १. जीवा (ग) (क) (ख) जीवा (च) for (जा)
२. रात्रार्द्ध (ग) (क) रात्रर्ध (ख) रात्रार्ध for (रात्र्यार्द्ध)
(ख) ३. चरदप्राण (वा) न् । for (चरदलप्राणान्)
४. स्वाषो for (स्वाधो)
५. च खंडंक प्राणाः for (चरखंडकप्राणाः)
(च) २. रात्रार्द्ध for (रात्र्यार्द्ध)
५. चरषंडक प्राणाः for (चरखंडकप्राणाः)

१५. (घ) १. रात्रार्द्ध क्रिय।द्यहो for (रात्रार्द्धक्रियाहो) (ख) रात्रार्धं for (रात्रार्द्धं)
२. राप्त (क) (ख) राप्त for (राप्तं)
(ग) ३. क्रियाद्य (क) क्रियाद्यहो (ख) क्रियाद्यहो for (क्रियाहो)
(क) ४. हृतं (च) for (हतं)
(ख) ५. रात्रदलं for (रात्रदल)
६. तज्याभि for (तज्ज्याभि)
७. चापंतराणि for (चापान्तराणि)
८. प्राणः for (प्राणाः)
(च) ३. क्रियाद्यहोरात्र for (क्रियाहोरात्र)
६. तद्याभिराप्त for (तज्ज्याभिराप्तं)

१६. (घ) १. वर्गोनात्पदाहृता (ग) वर्गो ना तत्पदाहृता for (वर्गोनात्तत्पदाहृता)
२. त्र्यज्या for (त्रिज्या)
३. हताः (ख) हतास्वाधाश् for (हृता)
४. ण्यथावाः for (ण्यथवा) (ख) चापांतराप्यथवा for (चापांतराण्यथवा)
(क) मूल श्लोक यहां उपलब्ध नहीं है । केवल टीका अंकित है ।
(ख) १. नात्यादा for (नात्तत्पदा)
(च) ५. ज्यावर्गान्त क्रान्तिज्या for (ज्यावर्गात्तत्क्रांतिज्या)
१. वर्गोनत्पदाहृता
३. हतास्चाधश् for (हताश्)

स्व[४]चरासुभि[१]सूनयुता १६१७[२] क्रमोत्[५] क्रमस्थैः[६] क्रमोक्रमन्यस्ताः[३] ।
उदयप्राणा व्यस्ताश्चार्कं[७] तात्कालिकं[८] कृत्वा ॥ १७ ॥[४]
र[६]विणा भु[३]क्त्याराशेः कला गु[७]णाः स्वोदयासुभि[८]र्भक्ताः ।
रा[९]शिकलाभि[५]र्लब्धा प्र[२]श्नासुभ्यो[१०]ऽशवः[१] शोध्याः ॥ १८ ॥

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१७. (घ) १. रूनयुताः (ग) रूनयुताः (क) (ख) नूनयुता for (सूनयुता)
२. +१७६५, १६३५, १६३५, १३६५, १६००+
३. क्रमोत्क्रमन्यस्ताः (ग) (क) क्रमोत्क्रमास्ते (ख) क्रमोक्रमन्यस्ताः for (क्रमोक्रमन्यस्ताः)

(ग) २. यहाँ कोई संख्या नहीं दी गई ।

(ख) ४. स्ववरासुभिः for (स्वचरासुभि)
५. क्रमाक्रमो for (क्रमोत्क्रमस्थै)
६. : विसर्ग लुप्त हैं
७. श्चार्क for (श्चार्कं)
८. 'कृत्वा' पद लुप्त है ।

(च) १. रूनयुताः for (सूनयुता)
३. क्रमोत्क्रमन्यस्ताः for (क्रमोक्रमन्यस्ताः)
७. चार्क्कं for (चार्कं)

१८. (घ) १. शवशोध्याः for (ऽशवःशोध्याः) (ग) सवः (क) ऽसवः (ख) सर्वं for (ऽशवः)
२. +१८००(ख) + : +

(ग) ३. भुक्ताराशेः (ख) for (भुक्त्याराशेः)
४. +१६७०, १७६५, १६३५, १६३५, १७६५, १६७०+
५. र्लब्धम् १८०० for (र्लब्धा) (क) लब्धाः for (र्लब्धा)·

(क) ६. रविभुक्तहीनराशेः for (रविणा भुक्त्या राशेः)

(ख) ७. गुणा for (गुणाः)
८. सुभिः भक्ताः for (सुभिर्भक्ताः)

(च) ६. ६+१७६५ २+१८००+
१६३५
१६३५
१३६५
१५००+
१०. अवग्रहचिह्नलुप्त

प्रक्षिप्य[६] राशय[२] भुवतं शेषा सुभ्यः क्रमेण[३] यावंतः[४] ।
शुद्धंत्फदया[१] सूर्ये तावंतो राशयः क्षेप्याः[५] ।। १९ ।
शेषांत्रिंशत्[१] गुणितानस्तन[२] शुद्धोदया[४] सुभिर्विभजेत्[५] ।
लब्धं[६] भागादिरवौ प्रक्षिप्य[३] तथा कृते लग्नम्[७] ।। २० ।।

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१९. (घ) १. शुध्यंत् (ग) शुध्यत्युदयाः (क) शुध्यंत्युदयाः (ख) for (शुद्धंत्फदया)

(ख) २. राश for (राश्य)

३. क्रमण for (क्रमेण)

४. यावतः for (यावंत)

५. 'क्षेप्याः' पदलुप्त है ।

(च) ६. +१७९५ } पिछले श्लोक के फुटनोट में संख्याएं दर्शा दीं गई हैं ।
१९३५
१९३५
१३९५
१५०९

१. शुद्धंत्युदयाः for (शुद्धंत्फदया)

२०. (घ) १. शेषांस्तृंशद् (ग) शेषास्त्रिशद् for (शेषांत्रिंशत्)

२. गुणिताः श्येनस्तन for (गुणितानस्तन) (ग) नसून for (नस्तन)

(क) दविशुद्धस्योदयाः for (नस्तनशुद्धोदया)

(क) ३. प्रक्षेप्यं for (प्रक्षिप्य)

(ख) १. शेषास्त्रिशद्गुणा for (शेषांत्रिंशत् गुणिता)

२. तसून for (नस्तन)

४. शुद्धासुभि for (शुद्धोदयासुभिर्)

५. वित्तजेत् for (विभजेत्)

६. लब्धा for (लब्धं)

(च) १. शेषात्रिंशद्गुणिताः ३० नस्तन for (शेषां त्रिंशत् गुणितानस्तन)

७. क्रम संख्या लुप्त

रवि[4]राशयभुक्तलिप्तास्तदुदय गुणिता हता[1] ग्रह[2]कलाभिः १८०० ।
लब्धं[5] प्राणा[6]स्थाप्याः प्रक्षिप्यार्के ग्रहा[3]भुक्तम् ॥ २१ ॥
तावत्सूर्ये राशि[1] न[4] क्षिपेत्समो[3] लग्नराशिभिर्यावत्[5] ।
क्षिप्र[2]ग्रहाणां प्राणान् प्रक्षिप्य स्थापितेष्वसुषु[7] ॥ २२ ॥
तदधिककालो[1]दयवध[3]राशि[8] कलाभिर्भजेत्[4] फलं[6] प्राणान् ।
प्रक्षिप्य प्राणेषु[9] प्राणाः[5] सूर्योदयादसकृत्[7] ॥ २३ ॥

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२१. (घ) १. हृतो (क) हृता (ख) कृता for (हतो)
२. गृहकलाभिः (ग) (क) (ख) गृहकालाभिः for (ग्रहकलाभिः)
३. गृहाभुक्तम् (ग) (क) (ख) गृहामुक्तम् for (ग्रहाभुक्तम्)
४. रविराश्यभुक्त (ग) (क) (ख) रविराशिभुक्त for (रविराशयभुक्त)
(ग) ५. लब्धप्राणाः (ख) लब्धां प्राणाः for (लब्धंप्राणा)
(क) ६. प्राणाः (ख) प्राणः for (प्राणा)
(च) ४. रविराश्यभुक्त for (रविराशयभुक्त) १ हृता for (हता) २ गृह for (ग्रह)
६. प्राणाः for (प्राणा) ३. गृहा for (ग्रहा)

२२. (ख) १. राशीन् (क) (ख) राशी for (राशिन)
२. क्षिप्तगृहाणां (ग) क्षिप्तगृणां (क) क्षिप्त गृहाणाँ for (क्षिप्रग्रहाणां)
(क) ३. समं for (समो)
(ख) ४. 'न' लुप्त
५. यावत् for (र्यावत्)
२. क्षिप्तगृहाणां for (क्षिप्रग्रहाणां)
(च) १. राशीन for (राशिन) २. गृहाणां for (ग्रहाणां)
६. स्थापितेष्वसुषुः for (स्थापितेष्वसुषु)

२३. (घ) १. कलोदय (ग) (क) (ख) कलोदय (च) for (कालोदय)
२. प्राणात् for (प्राणान्)
(ग) ३. वधं (क) (ख) for (वध)
४. भजेजेत् for (भंजेत्)
५. प्राणः (ख) for (प्राणाः)
(क) ६. फलप्राणान् (ख) फलप्राणान् for (फलंप्राणान्)
७. (……) ॥ २३ ॥
(ख) ८. राशिभिर्यावत् क्षिप्य गृहाणां प्राणान्प्रभिभजत् for (राशिकलाभिर्भजेत् फलं प्राणान्)
९. प्राणषु for (प्राणेषु)

प्रागुदयैः प्रश्नासुभिरूनोर्कौ भुक्तराशिभिर्लग्नम् ।
कृत्वैवमूनमर्कं लग्नसमं प्राग्भवेत्कालः ॥ २४ ॥
गतशेषाल्पास्याह्नः सौम्योत्तरगोलयोश्चरार्द्धेन ।
ऊनाधिकस्य जीवा स्वाहोरात्र्यार्द्धं संगुणिता ॥ २५ ॥
त्रिज्याहृता युतोना क्षितिज्यया सौम्ययाम्ययोश्छेदः ।
छेदोवलम्बकगुणो व्यासार्द्धं विभाजितः शंकुः ॥ २६ ॥

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२४. (घ) १. भुक्तः (ग) भुक्ति for (भुक्त)

(ग) २. प्रश्नाशुभि for (प्रश्नासुभि)
३. मूनमर्कं (ख) मूनमर्कलग्नसमं for (मूनमर्कं लग्नसमं)

(ख) ४. रुभोको for (रूनोर्कौ)
५. लग्नम् for (र्लग्नम्)
६. कलः for (कालः)

(च) ४. रूनोर्क्कौ for (रुनोर्कौ)[3] मर्क्कं for (मर्कं)

२५. (घ) १. गत शेषाल्पस्याह्नः (ग) गतशेखाल्पस्याह्नः for (गतशेषाल्पास्याह्नः)
२. सौम्येतर (ग) (क) (ख) सौम्यैतर for (सौम्योत्तर)

(ग) ३. रात्रार्द्धं (क) (ख) (च) for रात्र्यार्द्धं)

(क) १. गतशेषाल्पस्याह्नः (ख) गतशेषाल्पस्याह्नाः for (गतशेषाल्पास्याह्नः)

(ख) ४. चरार्द्धेनः for (चरार्द्धेनः)
५. ऊनाधिकास्य for (ऊनाधिकस्य)

(च) १. गतशेषाल्पस्याह्नः for (गतशेषाल्पास्याह्नः) २. सौम्येतर for (सौम्योत्तर)

२६. (घ) १. विभाजितशंकुः (च) for (विभाजितःशंकुः)
२. त्रिज्याहृता (च) for (त्रिज्याहृता)
३. छेदावलम्बकगुणो (च) for (छेदोवलम्बकगुणो)

(ग) ४. छेद (क) याम्ययोश्छेदः (ख) for (याम्ययोछेदः)

(ख) ५. व्यासार्धं for (व्यासार्द्धं)

विषुवत्कर्णविभक्तः[१] छेदो वा द्वादशाहृतः[३] शंकुः ।
शकुकृतिर्[२]विहीनाया व्यासार्द्धकृतेः पदं[४] दृग्ज्या ।। २७ ।।
दृग्ज्या द्वादश गुणिता[३] विभाजिता शंकुना[७] फल[१] छाया ।
व्यासार्द्धं[४] छेदहृतं[५] विषुवत्कर्णाहृतं[६] कर्णः[२] ।। २८ ।।
गुणितं वा द्वादशभिर्[२]व्यासार्द्धं शंकुनाहृतं[१] कर्णः ।
जीवा क्षयवृद्धिज्यायुतहीना ज्या[३] क्रियतुलादौ ।। २९ ।।

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२७. (घ) १. विभक्तं (च) for (विभक्तः)

२. शंकुकृतिविहीनाया (ग) (क) (ख) for (शकुकृतिर्विहीनाया)

(क) ३. हृतः (ख) हृतशंकुः for (हृतःशंकुः)

(ख) ४. फलं दृग्जा for (पदंदृग्ज्या)

(च) द्वादशहृतः for (द्वादशाहृतः)

२. शंकुकृतिविहीनाया for (शंकुकृतिर्विहीनाया)

२८. (घ) १. फलं (ग) (क) (ख) फलं for (फल)

२. कर्ण for (कर्ण)

३. +१२+(च)+१२+

(ग) ४. व्यासार्द्धछेदहृतं for (व्यासार्द्धं छेदहृतं)

(क) ५. हृतं (च) for (हृतं)

(ख) ७. शांकुला for (शंकुना)

२९. (घ) १. हृतं for (हृतं) (ग) (क) (ख) हृतकर्ण for (हृतंकर्णः)

(क) २. व्यासार्द्धं (ख) व्यासार्धं for (व्यासार्द्धं)

(ख) ३. जा for (ज्या)

स्वाहोरात्र्यर्द्ध गुणा व्यासार्द्धं विभाजिताऽथवा छेदः ।
शंक्वादि प्राग्वज्ज्या स्वाहोरात्र्यर्द्ध घात कृता ॥ ३० ॥
व्यासार्द्धकृति गुणिता विषुवत्कर्णेन वा भवेत्कर्णः ।
लम्बगुणो घातः शंकु व्यासार्द्धकृतिभक्तः ॥ ३१ ॥

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३०. (घ) १. रात्रार्द्ध (ग) (क) (ख) रात्रार्ध for (रात्र्यर्द्ध)

२. व्यासार्ध (ग) (ख) for (व्यासार्द्धं)

३. रार्द्ध (ग) (क) रात्रार्ध (ख) for (रात्र्यर्द्ध)

४. हृता (ग) (क) हृता (ख) हृता for (कृता)

(ग) ५. घात (क) (ख) for (धात)

६. शंकवादि for (शंक्वादि)

(ख) ७. गुण for (गुणा)

(च) १. रात्रार्द्ध for (रात्र्यर्द्ध) ४. हृता for (कृता)

३१. (घ) १. व्यासार्वकृति १०६६२६०० (ग) व्यासार्द्धकृति १०६६२६०० for (व्यासार्द्धकृति)

२. गुंणिता (ग) (क) (च) for (गुणिता)

३. भवति (ग) (क) (ख) (च) for (भवेत्)

४. व्याघातः (ग) (क) वा घातः (ख) वाघतः for (घातः)

५. कृतिवक्तः (ग) कृतिभुक्तः for (भक्तः)

(ग) ६. शंकुर्व्यासार्द्ध (क) (ख) शंकुव्यासार्ध for (शंकुव्यासार्द्ध)

(ख) १. व्यासार्धकृति १०६६२६०० for (व्यासार्द्धकृति) २. गुंणिता for (गुणिता)
४. व्याघातः for (घातः)

घातोवार्कगुणा[४] १२ स्त्रिज्या विषुवत्कर्ण[१]बंधः[२] हतः[३] शंकुः ।
कर्णकृते[५] संशोध्य[७] द्वादशवर्गं[८] १४४ पदं छाया[६] ।। ३२ ।।
अल्पप्रश्नासूनां[२] यदि बहवश्चरदलासवः क्षितिजा ।
हतयोना[१] जीवोना क्षयवृद्धिज्योक्तवच्छेषं[३] ।। ३३ ।।
स्वाहोरात्रार्द्धमुदकदक्षिणयोः[१] क्षितिज्यया[६] युतविहीनं ।
द्युदलान्त्यज्या[२]भिज्य[३] क्षयवृद्धिज्या[४] युतोनांत्या[५] ।। ३४ ।।

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३२. (घ) १. कर्णः (च) for (कर्ण)
२. वधः (ग) वध (क) for (बंधः) (ख) 'बंध' पद लुप्त है ।
३. हृतः (ग) (क) (च) for (हतः)
(ग) ४. गुणास्त्रिज्या (क) (ख) for (कृते)
५. कृतेः (क) (ख) गुणास्त्रिज्या for (गुणा १२ स्त्रिज्या)
६. छायाः for (छाया)
(क) संख्याएँ मूल में अंकित नहीं हैं ।
(ख) ७. संशोध्या for (संशोध्य)
८. वर्णगयछाया for (वर्गं १४४ पदं छायां)
(च) ४. घातोवार्क्कगुणा १२ for (घातोवार्कगुणा १२) २. वधः for (बंधः)
१. कर्णः for (कर्ण)

३३. (घ) १. हृतयोना (ग) (च) for (हतयोना)
(ग) २. अल्पप्रश्नासूना for (अल्पप्रस्नासूनां)
(क) मूल श्लोक अंकित नहीं है—केवल टीका लिखी हुई है ।
(ख) ३. छाषम् for (छेषम्)

३४. (घ) १. उदग्दक्षिणयोः (ग) स्वाहोरात्रामुदग्दक्षिणयोः (ख) for (स्वाहोरात्रार्द्धमुदकदक्षिणयोः)
(ग) २. द्युदलांतिज्या for (द्युदलान्त्यज्या)
३. त्रिज्या (क) (ख) त्रिज्या (च) for (भिज्या)
४. वृघ्य for (वृद्धिज्या)
५. नांत्याः for (नांत्या)
(क) १. स्वाहोरात्रार्धमुदग्दक्षिणयोः for (स्वाहोरात्रार्द्धमुदकदक्षिणयोः)
६. क्षितिजया (ख) षितिजयया for (क्षितिज्यया)
(च) १. मुदग्दक्षिणयोः for (मुदकदक्षिणयोः)

[1]छेदहृता द्युदलांत्या दिनार्द्ध[4]कर्णेन [2]वा कर्णः ।
भक्ता ज्यया ऽथवाऽन्त्या दिनार्द्ध कर्णा [3]हृता कर्णः ॥ ३५ ॥
द्युदलान्नतो [1]क्रमज्या [2]स्वाहोरात्र्यार्द्ध [4]संगुण विभजेत् ।
व्यासार्द्धेन [5]फलोना [3]द्युदलान्त्ययाथवा छेदः ॥ ३६ ॥
अन्त्यानतो [1]क्रमज्या हीनां ज्या षट् [2]पृथक् [3]छेदः ।
ज्याभ्यां [4]च सह [5]फलानि छाया नयनानि [6]षट् त्रिंशत् ॥ ३७ ॥

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३५. (घ) २. वा गुणा for (वा) (ग) संगुणा for (वा) (क) संगुणा for (वा) (ख) कर्णाः for (वाकर्णः)
१. छेदहृता (ग) (क) (च) for (छेदहृता)
(ग) ३. कर्णहृता (क) कर्णाहिता (ख) कर्णाः हृता for (कर्णाहृता)
(ख) ४. नवागुणाः for (र्द्धकर्णेन)
(च) २. वागुणाकर्णः for (वाकर्णः)

३६. (घ) १. द्युदलान्ततोत्क्रमज्यां (ग) (क) (च) for (द्युदलान्नतो क्रमज्या)
२. स्वाहारात्रार्ध संगुणं विभजेत् । (ग) स्त्राहोरात्रार्द्धसंगुणां विभजेत् for (स्वाहोरात्र्यार्द्ध संगुणा विभजेत्)
३. दलान्त्य ज्याथवा for (द्युदलान्त्ययाथवा)
(ग) ३. दलान्त्यज्या यथा (क) द्युदलान्त्यज्याथवा (ख) for (द्युदलान्त्ययाथवा)
(क) ४. संगुणाम् (ख) संगुणं for संगुणा
(ख) १. द्युदलन्नतोत्कमजां for (द्युदलान्नतो क्रमज्या)
२. स्वाहोरात्रार्द्ध for (स्वाहोरात्र्यार्द्ध)
५. फलेना for (फलोना)
(च) २. स्वाहोरात्रार्द्ध for (स्वाहोरात्र्यार्द्ध)
४. संगुणां for (संगुणा)

३७. (घ) १. अन्त्यानतोत्क्रमज्याहीना (ग) (क) (ख) for (अन्त्यानतो क्रमज्याहीनां)
३. छेदाः (ग) (ख) छेदा for (छेदः)
(च) ४. 'च' अतिरिक्त पाठ
५. फलनि for (फलानि)
६. त्प्रट्त्रिशत् for (षट्त्रिंशत्)
(च) १. अन्त्यानतोत्क्रमज्याहीन for (अन्त्यानतो क्रमज्याहीनां) ३ छेदाः for (छेदः)

छाया कर्णविभक्ता[4] विषुवत्कर्णेन संगुणा[2] नृज्या[1] ।
लब्धं सौम्येतरयोः[5] क्षितिज्यया[6] हीनसंयुक्तं[3] ॥ ३८ ॥
गुणितं व्यासार्द्धेन स्वाहोरात्रार्द्ध[1]भक्तमाप्तधनुः[2] ।
उत्तर गोले युक्तं याम्ये हीनं चरप्राणैः[3] ॥ ३९ ॥
दिनगतशेष[3]छेद[4]प्राणाः प्रागपरदिनार्द्धयोर्विशोध्याप्तम्[6] ।
व्यासार्द्ध[1]छेषो[5]क्रमजीवा चापं नताः[2] प्राणाः ॥ ४० ॥
स्वाहोरात्रार्द्धेन छायाकर्णाहतेन[2] भक्ताया[1] ।
विषुवत्कर्ण[3] गुणाया[4] व्यासार्द्धकृतेः[5] फलं सौम्ये ॥ ४१ ॥

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३८. (ग) १. त्रिज्या (क) (ख) त्रिज्या for (नृज्या)
(क) २. संगुण for (संगुणा)
३. संयुतम् (ख) for (संयुक्तं)
(ख) ४. विभक्त for (विभक्ता)
५. सौम्येतरयो for (सौम्येतरयोः)
६. ज्याया for (ज्यया)

३९. (ख) १. रात्रार्द्ध for (रात्रार्द्ध)
२. भक्तमप्तधनुः for (भक्तमाप्तधनुः)
३. प्राणै for (प्राणैः)

४०. (घ) १. व्यासार्द्धछिषोत्क्रम (ग) व्यासार्द्धातिशेषोत्क्रम for (व्यासार्द्ध छेषोक्रम)
२. नता (क) नत for (नताः)
(ग) ३. शेषप्राणः (क) शेषप्राणाः for (शेषछेद प्राणाः)
(क) ४. 'छेद' पद लुप्त है । (ख)
५. शेषोत्क्रम (ख) छेसोत्क्रम for (छेषोक्रम)
(ख) ६. विशोध्यप्तम् for (विशोध्याप्तम्)
(च) १. व्यासार्द्धछिषोत्क्रम for (व्यासार्द्ध छेषो क्रम)

४१. (ग) १. भक्तायाः (क) (ख) for (भक्ताया)
(ख) २. कर्णहतेन for (कर्णाहितेन)
(ख) ३. विषुवत्कर्णा for (विषुवत्कर्ण)
४. गुणाय for (गुणाया)
५. कृते for (कृतेः)

क्षयवृद्धिज्याहीनं युक्तं याम्ये धनुश्चरप्राणैः ।
सौम्येयुतं विहीनं याम्ये प्रागपरयोः प्राणाः ॥ ४२ ॥
अह्नोगताऽवशेषाः फलमन्त्याया विशोध्य शेषस्य ।
धनुरुक्रमजीवाभिः पूर्वापरयोर्नताः प्राणाः ॥ ४३ ॥
दिनदलकर्णगुणांत्या छायाकर्णोद्धृता फलोनान्त्या ।
शेषस्योत्क्रमजीवा धनुर्दिनार्द्धनताः प्राणाः ॥ ४४ ॥
चरदल जीवोनाधिक फल क्रमज्यो धनुश्चरार्द्धेन ।
युतहीनं पूर्वाह्ने दिवसगतं शेषं अपरार्द्धे ॥ ४५ ॥

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४२. (क) १. प्राणैः (ख) प्राणः for (प्राणः)
(ख) २. याम्यो for (याम्ये)
३. धनुशर for (धनुश्चर)
४. प्रणैं for (प्राणैः)
५. प्रागपरयो for (प्रागपरयोः)

४३. (घ) १. धनुरुत्क्रमजीवाभिः (ग) (क) (ख) (च) for (धनुरुक्रमजीवाभिः)
(ग) १. र्नता (क) नत for (र्नताः)
(क) ३. अह्नोगतावशेषात् (ख) अह्नोगतावशेषा for (अह्नोगताऽवशेषाः)
(ख) ४. प्राणः for (प्राणाः)
(च) ३. अवग्रहचिह्न लुप्त

४४. (घ) १. दिनार्द्धान्नताः for (दिनार्द्धनताः) (ग) (क) दिनार्द्धनत for (दिनार्द्धनताः)
(ग) २. नान्त्या (ख) नान्त्या for (नान्त्या)
(ख) ३, गुणांत्या
४. कर्णाद्धृता for (कर्णोद्धृता)
५. जीव for (जीवा)
१. दिनार्धोन्नतप्राणः for (दिनार्द्धनताः प्राणाः)
(च) १. धर्नुर्द्दिनार्द्धान्नताः for (धनुर्दिनार्द्धनताः)

४५. (घ) १. क्रमज्या (ग) (क) (ख) क्रमज्या for (क्रमज्यो)
२. शेषमपराह्णे (ग) (ख) शेषमपराह्ने (च) for (शेषं अपराह्ने)
(ग) ३. पूर्वाह्णे (ख) पूर्वाह्न for (पूर्वाह्ने)
(ख) ४. विवसगतं for (दिवसगतं)

उत्क्रमजीवाभ्यधिक क्रमज्यया[४] संयुक्तं[१] (तं) धनुर्धनुषां[६] ।
व्यस्त[५]विशुद्धौ हीनाश्चरांसवः[२] पूर्ववच्छेषं[३] ॥ ४६ ॥
दिनमध्यार्का[१] क्रांत्याक्ष[२]भागयोगांतरं सामान्यदिशोः[४] ।
नतभागा[६] नवते प्राक्[५] ज्योन्नताः[३] शेषाः[१] ॥ ४७ ॥
नतभागज्या द्वादशगुणोन्नतांश[४]ज्यया[५] हृताल्लब्धम्[१] ।
इष्टदिनार्द्धछाया यथोक्तकरणौ[२]दिनार्द्धाद्वा[३] ॥ ४८ ॥

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४६. (घ) १. संयुतम् (ग) (क) (ख) संयुते for (संयुक्तं)
२. चरासवः (ग) (क) (ख) (च) for (चरांसवः)
३. पूर्ववछेषं (ग) पूर्ववत्सेषम् for (पूर्ववच्छेषं)
५. व्यक्त for (व्यस्त)
(ज) १. संयुतं for (संयुक्तं) ६. धनुर्द्धनुषा for (धनुर्धनुषां)
४७. (घ) १. दिनमध्यार्क (ग) (क) (ख) for (दिनमध्यार्का)
२. क्रान्त्यक्ष (ग) (क) (ख) for (क्रांत्याक्ष)
६. नतभागानतभान्नवते ९० (ग) नतभागानतभागान्नवतेः for (नतभागानवते)
३. प्रोन्नताः (ख) प्रोज्योन्नतभागास्तु for (ज्योन्नताः)
(ग) ४. समान्यदिशोः (क) समानदिशोः (ख) समान्यादिशोः for (सामान्यदिशोः)
५. प्रोह्योन्नताः शेषा (क) (ख) देखो ३. for (प्राक्ज्योन्नताः शेषाः)
(क) ६. नतभागा नतभागोन्नवतेः (ख) नतभागान्नवतेः for (नतभागानवते)
(ख) ७. शाय्याः स्युः for (शेषाः)
(च) १. दिनमध्यार्क्का for (दिनमध्यार्का)
२. क्रांत्यक्ष for (क्रांत्याक्ष)
४. समान्यदिशोः for (सामान्यदिशोः)
६. नतभागानतभागान्नवते ९० for (नतभागानवते)
४८. (घ) १. हृता (ग) (क) (ख) हृतालब्धम् for (हृताल्लब्धम्)
२. करणौं (ख) करणे for (करणौ)
३. दिनार्धा (ग) दिनार्द्धाद्वा (क) दिनार्धाद्वा for (दिनार्द्धाद्वा)
(ग) ४. द्वादगुणोन्नतांश (ख) द्वादशगुरोन्नतांश for (द्वादशगुणोन्नतांश)
(ख) ५. ज्याया for (ज्यया)
३. दिनार्धद्वा for (दिनार्द्धाद्वा)
(च) १. हृतालब्धं for (हृताल्लब्धम्)
२. कर्णौं for (करणौ) ३. दिनार्द्धा for (दिनार्द्धाद्वा)

उन्नतजीवाभक्त[४] व्यासार्द्धं[५] द्वादशाहृतं[३] कर्णः ।
मध्यछायाकर्ण[१] द्वादशक्रान्त्यतरं[२] पदं वा ॥ ४६ ॥
कुदलां[१]त्याज्या[२] छेदोमध्यछाया यथोक्तकरणैर्वा[३] ।
अन्त्याज्या[४] छेदाद्यं मंध्यछाया[५]ऽथवा[६] बहुधा ॥ ५० ॥
विषुवत्कर्णेन[६] गुणा विषुवत्छाया[१] हतोत्तरा[२] क्रान्तिः ।
यद्युनाक्षक्षज्याया[३] शंकु[५]सम[४]मंडलस्थेऽर्के[७] ॥ ५१ ॥

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४६. (घ) १. छायाम् for (छाया)
२. कृत्यंतरपदम् (ग) (क) कृत्यन्तरपदं वा for (क्रान्त्यतरं पदं वा)
३. द्वादशाहृतं ११ for (द्वादशाहृतं)
(ग) ४. भुक्तं for (भक्तं)
(ख) ५. व्यासार्धं for (व्यासार्द्धं)
१. 'मध्यछायाकर्णं' पद लुप्त हैं ।
२. कृतंतर for (क्रान्त्यतरं) यहां दूसरी पंक्ति 'द्वादश' से आरम्भ है ।
(च) १. छायां for (छाया) २. कृत्यंतरपदं वा for (क्रान्त्यतरं पदं वा)
५०. (घ) १. द्युदलां (ग) (क) (ख) (च) for (कुदलां)
(ग) २. त्यज्या (क) (ख) for (त्याज्या)
३. वरणैर्वा (ख) करणै वाः for (करणैर्वा)
(क) ४. अन्त्यज्या (ख) अत्याज्याः for (अन्त्याज्या)
(ख) ५. मध्यछाया for (मंध्यछाया)
(च) ६. अवग्रह चिह्न लुप्त
५१. (घ) १. विषुवछाया (ग) (ख) विषुवच्छाया for (विषुवत्छाया)
२. हृतोत्तरा for (हतोत्तरा) (क) छायोद्धृतोत्तरा for (छायाहृतोत्तरा)
३. यद्यूनाक्षय्याया (ग) द्यूनाक्षज्यायाः (क) यद्यूनाक्षज्यायाः for (यद्युनाक्षक्षज्याया)
४. समं (च) for (सम)
(ग) ५. शंकुः (क) (ख) 'शंकु' लुप्त पद for (शंकु)
(क) ६. बिषुवत्कर्णा for (विषुवत्कर्णेन)
३. यद्यूनाक्षज्यायाः for (यद्यूनाक्षक्षज्याया)
७. मंडलास्थेर्के for (मंडलस्थे ऽर्के)
(च) १. विषुवछाया for (विषुवत्छाया)
२. हृतोत्तरा for (हतोत्तरा) ३ यद्यूनाक्षज्याया for (यद्युनाक्षक्षज्याया)

सूर्यज्या जिनभागज्यया गुणाक्षज्ययाऽथवा भक्ता ।
अग्रा द्वादशगुणिता विषुवच्छाया विभक्ता वा ॥ ५२ ॥
द्वादश विषुवच्छाया गुणिते पृथगक्षलंबजीवे वा ।
क्रान्तिहृते सममण्डलकर्णौ प्राग्वत् पृथक् छाया ॥ ५३ ॥
अर्काग्रा वर्गोनं नृज्या वर्गार्धं ५३४६४५० मर्क १४४ कृतिगुणितं ।
आद्यान्योग्रा द्वादशविषुवच्छाया वधो हृतयोः ॥ ५४ ॥

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५२. (घ) १. ज्ययाथवा (च) for (ज्ययाऽथवा)
२. विषुवछाया (ग) for (विषुवच्छाया)
(ग) ३. दिनभागज्यागुणा for (जिनभागज्यया गुणा) (ख)
(क) ४. अग्रात् (ख) अग्र for (अग्रा)
(ख) ५. गुणाक्षयाथवा for (गुणाक्षज्ययाऽथवा)
६. 'ज्यया' लुप्त पद है ।
७. विभक्त for (विभक्ता)
(च) २. विषुववछाया for (विषुवच्छाया)

५३. (घ) १. विषुवछाया (ग) (च) for (विषुवच्छाया)
२. हृते (ग) (क) (च) for (हृते)
३. छाये for (छाया) (ग) (ख) पृथकार्ये for (पृथक् छाया)
(ख) ४. पृस्थगक्ष for (पृथगक्ष)
५. कर्णौ for (कर्णौ)
(च) ३. छायो for (छाया)

५४. (घ) १. वर्ग्राधा ५३४६४५० for (वर्गार्धं ५३४६४५०) (ग) वर्ग्राधं (ख) वर्गा for (वर्गार्धं)
२. मर्काकृतिगुणितं १४४ (ख) धर्मकृति for (मर्क १४४ कृतिगुणितं)
३. आद्योन्योग्रा (ग) (क) (ख) आद्योन्योग्रा (च) for (आद्यान्योग्रा)
४. विषुवछाया (ग) (च) for (विषुवच्छाया)
५. हृतयोः (ग) (क) (ख) हृतयो for (हृतयोः)
(ग) ६. वर्ग्रोनं for (वर्गोनं)
७. त्रिज्या (क) (ख) for (नृज्या)
वि० श्लोक में दी गई संख्याएं इस प्रति में नहीं है ।
(क) १. वर्गाधमर्क कृति for (वर्गार्धं ५३४६४५० मर्क १४४ कृति)
(च) ८. अर्क्काग्रा for (अर्काग्रा) ६ वर्गोनं for (वर्गोनं)
१. वर्ग्राद्धं ५३४६४५० for (वर्गार्धं ५३४६४५०) २ मर्क्क कृतिगुणितं १४४ for (मर्क १४४ कृति गुणितं)
५. हृतयोः for (हृतयोः)

वि[1]षुवच्छाया कृत्या[3]द्वा सं[2]गयुतया ७२ न्यकृतियुतादा[6]द्यात् ।
[4]पदमन्ययुतविहीनं सौम्ये[5]त्तरगोलयोः शंकुः ।। ५५ ।।
वि[1]दिशोः सौ[6]म्येत्तरयोरु[2]त्तरगोले पदोनयु[5]क्तो न्यः ।
सममण्डल दक्षि[4]णतोत[3]च्छाया नाडि[7]काः प्रागवत् ।। ५६ ।।
प्रा[3]च्यपरा शंकुतलान्तरद्वयव्यस्तकर्णवधविवरं ।
समदिग्विषु[1]वत्छायान्यदिगैक्यं कर्णविव[2]रहृतम् ।। ५७ ।।

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५५. (घ) १. विषवछाया, (ग) for (विषुवच्छाया)
२. गसंयुतया ७२ for (संगयुतया ७२)
(ख) ३. कृत्या: व्यागसंयुतया for (कृत्याद्वा संगयुतया ७२)
(ग) ३. कृत्याद्वचग ७२ संयुतया (क) for (कृत्या द्वासंगयुतया)
४. परमन्यतयुत (ख) पदमन्ययुतं for (पदमन्ययुत)
(ख) ६. युतयाद्यात् for (युतादाद्यात्)
(च) १. विषुवछाया for (विषुवच्छाया) २. गसंयुतया ७२ for (संगयुतया ७२)

५६. (घ) १. विदिशो सौम्येतरयो (ग) विदशो सौम्येतरयो (क) for (विदिशोः सौम्येतरयो)
२. रुत्तरागाले (क) रुत्तरागोले for (रुत्तरगोले) (ख) गोपदोन for (गोलेपदोन)
३. तच्छाया (क) नच्छाया (ख) तच्छाया for (तच्छाया)
(ग) ४. दक्षिणागतछाया (क) दक्षिणगे (ख) दक्षिणगो for (दक्षिणतो)
(क) ५. ऽन्यः । (ख) युक्ता यः for (युक्तोन्यः)
(ख) १. वेदि for (विदिशोः)
६. शौम्येतरयो for (शौम्येतरयो)
७. नाहिका for (नाडिकाः)
(च) १. विदिशो for (विदिशोः) ३. तछाया for (तच्छाया)

५७. (घ) १. विषुवछाया (ग) (क) विषुवच्छाया for (विषुवत्छाया)
२. कर्णविवरहृतम् (ग) कर्णविवरहृतम् for (कर्णविवरहृतम्)
३. यात्यपरा (ग) प्राच्यापरा for (प्राच्यपरा)
(च) १. विषुवच्छाया for (विषुवत्छाया) २. कर्णविवरहृतम् for (कर्णविवरहृतं)

छायावृत्ताग्रोमा सौम्येन युगान्तरेण याम्येन ।
विषुवच्छायाज्जादिषु तुलादिषु तथान्तरं हीनं ॥ ५८ ॥
इष्टाछाया वृत्ते तदग्रयो यदुदयास्तमयसूत्रम् ।
अनुपातात छंको विषुवत्छायांतरमिहऽग्रा ॥ ५९ ॥
शंकुप्राच्यपरांतरविषुवत्छायांऽगुलांतरं याम्ये ।
उदगैक्यं लम्बगुणं छाया-कर्णोद्धृतं क्रान्तिः ॥ ६० ॥

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५८. (घ) १. विषुवछाया (ग) (च) for (विषुवच्छाया)
२. जादिषु (क) (च) for (ज्जादिषु)

(ग) ३. ग्रोना (क) for (ग्रोमा)
४. तयान्तरं for (तथान्तरं)

(क) ५. युतांऽतरेण for (युतांतरेण)

५९. (घ) १. अनुपातात्तच्छंको (ग) अनुपातात्तच्छंको for (अनुपाततछंको)
२. विषुवछाया for (विषुवत्छाया) (ग) विषुछायांतरमिहाग्रा (क) for (विषुवत्छायांतरमिहऽग्रा)
३. इहाग्रा for (इहऽग्रा)
४. इष्टछाया (ग) (क) for (इष्टछाया)

(ग) ५. तदग्रया for (तदग्रयो)

(क) ६. यंदुदयास्तमयं for (यदुदयास्तमय)

(च) १. अनुपातात्तछंको for (अनुपाततछंको)
२. विषुवछायांतर for (विषुवत्छायांतर)
३. मिहाग्रा for (मिहऽग्रा)

६०. (घ) १. विषुवछायां for (विषुवत्छायां) (ग) (क) विषुवच्छायांतरं for (विषुवत्छायांऽगुलातरं)
२. छायांगुलांतरम् (ग) for (छायांऽगुलांतरं)
४. क्राँति for (क्रान्तिः)

(क) १. विषुवछायां for (विषुवत्छायां) २. गुलांतरं for (ऽगुलांतरं)

क्रान्तिव्यासार्द्धगुणा ३२७० जिनभागज्या १३२६४ हतातुरजादौ ।
कर्कादौ चक्रार्द्धात्प्रोक्ततुलादौ स चक्रार्द्धं ॥६१॥
चक्रात्प्रोह्य मृगादौ स्फुटो सकृत् व्यस्तमृणं धनंमध्यम् ।
अर्कास्माद्देशान्तरयुगयाते मध्यमा प्राग्वत् ॥ ६२ ॥

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६१. (घ) १. क्रान्तिर्व्यासार्धं गुणाः (ग) क्रान्तिर्व्यासार्द्धं गुणा (क) for (क्रान्तिव्यासार्द्ध गुणा)

२. कर्क्यादौ (ग) (क) (च) for (कर्कादौ)

३. प्रोत्तुलादौ (ग) प्रोह्य (क) for (प्रोक्ततुलादौ)

४. वक्रार्धम् (क) चक्रार्द्धं (सभार्धेन) for (चक्रार्द्धं)

५. १३२६ for (१३२६४)

६. धनुरजादौ (ग) हृता धनुरजादौ (क) for (हतातुरजादौ)

(च) १. क्रांतिर्व्यासार्द्धं for (क्रांन्तिव्यासार्द्धं)

७. गुणाः for (गुणा) ६. हृता १३२६४ नुरजादौ for (१३२६४ हतातुरजादौ)

६२. (घ) १. प्रामृगादौ for (प्रोह्यमृगादौ) (क) ऽऽऽत्प्रास्य for (प्रोह्य)

२. अर्को (ग) (क) मध्यर्कोऽस्य for (अर्कास्माद्)

३. मध्यमाः for (मध्यमा)

४. मध्यः (ग) (च) for (मध्यम्)

(ग) ५. ऽसकृत् (क) ऽशकृद् for (सकृत्)

(क) ६. व्यस्तधनयुषं for (व्यस्तमृणंधनं) (चं) मृण for (मृणं)

७. हेशातरयगया तेन for (देशान्तरयुगयाते)

(च) १. चक्रात्प्रोज्य for (चक्रात्प्रोह्य)

२. अर्क्कोस्मादेशांतर for (अर्कास्माद्देशांतर)

८. प्रागवत for (प्राग्वत्)

शशिमृगोन्यत्यर्धे[१] रात्रेर्गतशेषनाडिका[२] शंकु[३]।
विपरीतगोलविधिना[५] रात्र्यर्द्धा[४] क्रान्तिराभिर्वा ॥ ६३ ॥
क्षितिजेऽग्रा प्राच्यपराक्रान्तिस्त्रिज्यागुणावलम्ब[२]हृता[१]।
द्विगुणमुदयास्तसूत्रं[४] तत्त्रिज्या कृतिविशेषपदम्[३] ॥ ६४ ॥
अक्षज्या शंकु[३]वधालम्बक[१]लब्धोदयास्तमयसूत्रात्[२]।
दक्षिणतः शंकुतलं दिवसो रात्रौ तदुत्तरतः ॥ ६५ ॥
दिग्लम्बाक्ष[१]स्वोदयलग्नछायादिषु यदिष्टेषु[२]।
षट् षष्टयार्याणां त्रिप्रश्नाध्यायस्[३]तृतीयोयम्[४] ॥ ६६ ॥

इति ब्रह्मगुप्ते तृतीयोऽध्यायः

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६३. (घ) १. शृंगोन्नत्यर्थं (ग) शृंगोन्यत्यर्थं (क) शृगोन्नत्यर्थं for (शशिमृगोन्यत्यर्धे)
२. नाडिकाम् for (नाडिका)
३. शंकुः (ग) (क) for (शंकु)
४. रात्र्यार्धक्रंतिराभिर्वा (ग) क्रंतिराभिर्वा (क) कोन्तराभिर्वा for (रात्र्यर्द्धा क्रान्तिराभिर्वा)
(ग) ५. विपरीतगेलविधि for (विपरीतगोलविधिना) (च) विपरित for (विपरीत)
(च) १. शृंगोन्यत्यर्थं for (शशिमृगोन्यत्यर्धे)
४. रात्र्यार्धक्रींतराभिर्वा for (रात्र्यर्द्धाक्रान्तिराभिर्वा)
६४. (क) १. हृता (क) (च) for (हृता)
(ग) २. गुणवलंबहृता for (गुणावलम्बहृता)
(क) ३. वियुक्तपदम् for (विशेषपदम्)
(च) ४. त्सूत्रं for (सूत्रं)
६५. (घ) १. शंकुवधाल्लंबक for (शंकुबधालम्बक) (ग (क)
(ग) २. लब्धोदयस्तसूत्रात् for (लब्धोदयास्तमयसूत्रात्)
(क) ३. शंकुः for (शंकु)
६६. (घ) १. दिल्लंवाक्ष for (दिग्लम्बाक्ष)
(ग) २. छायादिषूपदिष्टेषु (क) (च) for (छायादिषु यदिष्टेषु)
३. त्रिप्रस्नाध्यायः for (त्रिप्रश्नाध्यायस्)
(क) ४. तृतीयोऽयम् for (तृतीयोयम्)
(च) ४. त्रतीयोयं ॥३॥ for (तृतीयोयं ॥६६॥)
वि० श्लोक क्रमांक ६६ के स्थानपर 'तीन' का अंक अध्याय की क्रम संख्या को दर्शाता है।

कालज्ञानं प्रायः पर्वज्ञानार्थमिष्यते सद्भिः ।
शशिभास्करग्रहणयोस्तद्भि[1] व्यक्तिः स्फुटाभेदैः[2] ॥ १ ॥
दिग्वर्णवलनवेलायां[1] निमिलनोन्मीलन[3]स्थितिविमर्दाः ।
स्पर्श-छाया-मोक्ष-ग्रासेष्ट-ग्रास-परिलेखा[2] ॥ २ ॥
भेदाश्चतुर्दश[4] तयोरिन्द्वर्कग्रहणयोः[5] परिज्ञानात्[1] ।
यस्माद्भेदज्ञानं तस्माद् ग्रहणं[2] प्रवक्षामि[3] ॥ ३ ॥
तिथिगतगम्ये भुक्ति[1] [4] भुक्तचंतरहते[2] फलोनयुतौ ।
रविशशिनौ समलिप्तौ यातस्तात्कालिको[3] भवति ॥ ४ ॥

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१. (घ) १. तदभिव्यक्तिः (ग) for (तद्भिव्यक्तिः)

(क) १. स्वदभिव्यक्तिः for (तद्भिव्यक्तिः)

(च) १. तदभिव्यक्तिः for (तद्भिव्यक्तिः)

२. (घ) १. खला निमीलानान्मीलन (ग) वेला निमीलनोन्मीलन for (वेलायां निमिलनोन्मीलन)

(क) मूलश्लोक यहाँ उपलब्ध नहीं, हाँ उसकी टीका दी हुई है ।

(च) ३. निमीलनोन्मीलन for (निमिलनोन्मीलन)

३. (घ) १: परिज्ञानात: for (परिज्ञानात्)
२. ग्रहणे (ग) (क) for (ग्रहणं)
३. प्रविक्ष्यामि (ग) (क) प्रवक्ष्यामि for (प्रवक्षामि)

(ग) ४. भेदश्चतुर्दश for (भेदाश्चतुर्दश)
५. ग्रहणयो for (ग्रहणयोः)

(च) २. दृग्रहणे for (दृग्रहणं) ३ प्रविक्ष्यामि for (प्रवक्षामि)

४. (घ) १. गुणेभुक्तचंतर for (भुक्तचंतर)
२. हृते (क) (च) for (हते)

(क) १. यहाँ 'भुक्ति' के आगे 'गुणे' अधिक पद है
३. पातस् (च) for (यातस्)

(च) ४. +गुणे+

खत्रिघन (घ्न) गुणा व्यासार्द्ध भाजिता ३२७० चन्द्रपातयोगज्या ।
विक्षेपकालाः सौम्याः षट् राश्यूनधिके याम्याः ॥ ५ ॥
रविशशिभुक्ती भवदशगुणे नख स्वरजिनैः हृते नात्ते ।
तत्वाष्टगुणितभुत्तचोर्विवरं षष्ट्याहृतं तमसः ॥ ६ ॥
छाद्यं छादक मानैक्यार्धं विक्षेप हृनिकं हृन्नं $\frac{११}{२०}$ $\frac{१०}{२४}$ ।
सर्वग्रहणं ग्राह्यादधिके खण्डग्रहणमूने ॥ ७ ॥

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५. (च) १. षड्राश्यूने धिके (ग) षड्राशूनेधिके (क) षड्राश्यूनेऽधिके for (षट्राश्यूनधिके)
(ग) २. विभाजिता for (भाजिता)
३. ज्याः for (ज्या)
४. +२७०+
५. कलाः (क) for (कालाः)
(च) ६. सौम्या for (सौम्याः)

१. षड्राशूनधिके for (षट् राश्यूनधिके)

६. (घ) १. नखैः (क) (च) for (नखैं)
२. हृते (ग) (क) (च) for (हृते)
३. माने (ग) (क) (च) for (नात्ते)
४. षष्ट्याहृतमंतरं तमसः (ग) षष्ट्याहृतं तसमः for (षष्ट्याहृतं तमसः)
(ग) ५. गुणैः ११।१०। for (गुणे)
६. जिनै २०।२४७ (क) जिनै for (जिनैः)
७. तत्वाष्ट २५।८ (क) तत्त्वाष्ट for (तत्वाष्ट)
(क) ८. भुक्तयो विवरं for (भुत्तचोर्विवरं)
९. षष्ट्याहृतं for (षष्ट्याहृतं)

७. (घ) १. छाद्य-(ग) (क) for (छाद्यं)
२. हीनकं (ग) (क) (च) for (हृनिकं)
३. छन्नं । (ग) छिन्नम् (क) छन्नम् (च) for (हृन्नं)
४. षण्ड (क) for (खण्ड)

(च) वि० इस श्लोक के बाईं ओर "$\begin{array}{c|c} ११ & १० \\ २० & २४ \end{array}$" संख्यासारणी अंकित है ।

छाद्य न युतो[4]नस्य छा[1]दकमानस्य तद्दलकृतिभ्याम् ।
विक्षेपकृ[2]त्ति प्रोह्य पदेति व[3] स्थिति विमर्दार्द्धे[5] ॥ ८ ॥
षष्ट्या विभाजिता स्थितिविमर्दार्द्ध[1] नाडिका गुणाः[5] स्वगतिः ।
आदौ रवि[6]शशिपाते[2]षूणमसकृ[3]तेषु धनमंते[4] ॥ ९ ॥
स्पर्शान्नि[1]मीलनं स्थितिदले विमर्दार्द्ध हीनके पश्चात् ।
मो[3]क्षादर्वागुन्मीलनं विमर्द्द[2]स्तयोरै[4]क्यम् ॥ १० ॥
भुक्त्यन्तरमिष्टोनस्थितिदलघटिका गुण[4]हतं[1] षष्ट्या ।
बा[2]हुः प्राग्वत् तत्फ[5]लहीनयुतैः सूर्य[3]शशिः पातैः ॥ ११ ॥

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८. (घ) १. छदक for (छादक)
२. कृति (ग) for (कृत्ति)
३. तिथिवत् (ग) (क) for (तिवस्थिति)
(क) ४. युतोनास्य for (युतोनस्य)
५. विमर्दाधे for (विमर्दार्द्धे)
(च) २. कृति for (कृत्ति) ३ थिवस्थिति for वस्थिति)

९: (घ) १. विमर्ददलनाडिका (ग) (क) for (विमर्दार्द्धनाड़िका)
२. ३. पातेष्वृणमसकृत्तेषु (ग) (क) (च) for (पातेषूणमसकृतेषु)
४. धनमन्तेः for (धनमंते)
(ग) ५. गुणास्वतिः । (क) गुणास्वगतिः for (गुणाः स्वगतिः)
(क) ६. रवींदु for (रविशशि)

१०. (घ) १. निमीलिनं (च) for (न्निमीलनं)
(ग) २. तदर्द्धैक्यम् (क) तदैक्यार्धः for (तयोरैक्यम्)
(च) ३. माक्षा for (मोक्षा)
४. रेक्यम् for (रैक्यम्)

११. (घ) १. हृतं (ग) (क) (च) for (हतं)
२. बहुः for (बाहुः)
३. सूर्यशशिपातैः (ग) (क)
(ग) ४. गुणं for (गुण)
(क) ५. तत्फलं for (तत्फल)
३. सूर्यशशिपातैः for (सूर्यशशिः पातैः)

तात्कालिकविक्षेपः कोटिस्तद्वर्ग[1]युतिपदं कर्णः ।
मानैक्यार्द्धात्कर्णं विशोध्य तात्कालिको ग्रासः ॥ १२ ॥
असकृत्[1] ग्रासकालोनप्रमाणयुतिदलकृते [6]विशोध्य कृतिं[4] ।
तत्[2]कालिकविक्षेपस्य शेषमूल[3]कृतं तिथिवत्[5] ॥ १३ ॥
प्रग्रहण स्थित्यार्द्धात्[4] प्राज्यप्रग्रहणतो भवति कालः ।
मौक्षे विशोध्य मोक्षस्थित्यर्द्धात्प्राग् भवेत्[3] मोक्षम्[2] ॥ १४ ॥
स्फुटतिथ्यंते मध्यं प्रग्रहणं[2] स्थिति[3]दलोनकेभ्य[1]ऽधिके ।
मोक्षो निमीलनोन्मीलने विमर्दार्ध[4]हीनयुते[6] ॥ १५ ॥

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१२. (घ) १. तद्वर्ग्रयुति (ग) तद्वर्ग्र संयुति for (तद्वर्गयुति)

१३. (घ) १. असकृद्ग्रासकलोन (ग) असकृग्रास कलोन for (असकृत्ग्रासकालोन)
२. तात्कालिक (ग) (च) for (तत्कालिक)
३. शेषमूलं (च) for (शेषमूल)
(ग) ४. कृति for (कृतिं)
५. तितिवत् for (तिथिवत्)
(क) १. असकृद्ग्रासकालोन for (असकृत् ग्रासकालोन)
(च) १. असकृद्ग्रासकलोन for (असकृत्ग्रासकालोन)
६. विशोध्य for (विशोध्य)

१४. (घ) १. प्रग्रणतो (ग) प्राज्यप्रग्रहणतो (क) प्रोज्य प्रग्रहणवो for (प्राज्यप्रगणतो)
२. मोक्षात् (ग) (च) for (मोक्षम्)
(ग) ३. भवेन् (क) for (भवेत्)
(क) ४. स्थित्यर्धात् for (स्थित्यर्द्धात्)
५. मोक्षं for (मोक्षे)
(च) १. प्राज्य प्रग्रहणतो for (प्राज्यप्रगणतो)

१५ (घ) १. दलोनवच (क) दलोनकेऽभ्यधिके for (दलोनकेभ्यऽधिके)
(ग) २. प्रग्ग्रहणं for (प्रग्रहणं)
३. स्थितिददलोनकेभ्यधिके for (स्थितिदलोनकेभ्यऽधिके)
(च) १. अवग्रहचिन्हलुप्त ४. विमर्द्दार्द्ध for (विमर्दार्ध)

प्राग् पश्चान्नतविषुवज्यो वंधा त्रिज्ययाप्तचापांशैः ।
उत्तरयाम्यैः पूर्वा विषुवद् वृतत्रिभे ग्राह्याः ॥ १६ ॥
सममंडलविषुवतो ग्राह्या त्रिगृहाधिकादुदग्याम्यैः ।
क्रान्त्यंशैरपममंडलपूर्वास्याञ्चन्द्रविक्षेपः ॥ १७ ॥
एकान्यदिशायुतिवियुतेर्ज्या प्रगृहणमध्यं मोक्षेषु ।
वलनं निमीलनोन्मीलनेष्टकालेष्टवो ऽन्येदिशां ॥ १८ ॥

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१६. (घ) १. प्राक् (ग) (क) (च) for (प्राग्)
२. विषुवज्ययो (ग) (क) (च) for (विषुवज्यो)
३. वंधात्त्रिज्यया (ग) (क) (च) for (वंधात्रिज्यया)
४. पूर्वादिषु for (पूर्वाविषुवद्)
५. वृत्त (ग) वृत् for (वृत)
६. ग्राह्या (क) for (ग्राह्याः)

(क) ७. पश्चात् विषुवज्ययो for (पश्चान्नतविषुवज्यो)
८. याम्यै for (याम्यैः)
९. त्रिमे for (त्रिभे)

१७. (घ) १. सममंलाद्विषुवतो (ग) for (सममंडलविषुवतो)
२. त्रिगृहाधिका (ग) for (त्रिग्रहाधिका)
३. पूर्वास्याश्चन्द्र (ग) (क) (च) for (पूर्वास्याञ्चन्द्र)

(क) १. सममंडलाद्विषुवतो for (सममंडलविषुवतो)

१८. (घ) १. न मीलानान् for (निमीलनोन्)
२. कालेष्वतोऽन्यदिशाम् (ग) (च) for (कालेष्टवोऽन्येदिशां)

(ग) ३. एकान्यदिशां (च) for (एकान्यदिशा)
४. विमलं for (वलनं)

(क) अवराम्यदिशाँ ज्यातिहि कुतज्यप्रग्रहणमध्यमोक्षेषु ।
वलनं निमीलनोन्मीनानष्टकालेष्टतोऽम्यदिशांम् ॥ १८ ॥

(च) २. कालेष्वतोन्यदिशां for (कालेष्टवोऽन्येदिशां)

आद्यन्त्ययोः सधूम्रः कृष्णः खण्डगृहेऽर्द्धतोभ्यधिके गृासः ।
सकृष्न (ष्ण) ताम्रः सर्वगृहणे शशिकपीलवर्णः ॥ १९ ॥
मानविमर्दस्थितिदलवलनेष्ट गृास समकलाद्येषु ।
चन्द्रगृहणाध्याय विंशतिरार्या श्चतुर्थोयां ॥ २० ॥

इति ब्रह्मगुप्ते चतुर्थोऽध्यायः

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१९. (घ) १. आद्यन्तयोः (ग) (क) for (आद्यन्त्ययोः)

२. घण्डग्रहे (ग) for (खण्डग्रहे)

३. ऽर्केतोभ्यधिके for (ऽर्द्धतोभ्यधिके)

४. ग्रासः (दूसरी पंक्ति का आरम्भ) (ग) (क)

५. शशी (ग) (क) (च) for (शशि)

६. कपिलाँ (ग) कपिलवर्णः (क) कपिलः for (कपिलवर्णः)

७. वर्णः (यह शब्द नहीं है) (क) 'वर्ण' पद लुप्त

(ग) ८. सुधूम्र for (सधूम्रः)

(च) ३. र्द्धेतोभ्यधिके for (र्द्धतोभ्यधिके) ६. कपिल for (कपील)

२०. (घ) १. दवलनेष्ट for (दलवलनेष्ट)

२. चन्द्रग्रहणाध्यायो (ग) (क) for (चन्द्रग्रहणाध्याय)

३. चतुर्थोयम् । (ग) (क) for (चतुर्थोयां)

५. 'इति' से 'अध्यायः' तक अंकित नहीं । केवल अध्याय समाप्ति सूचक "छः" अंकित है ;

(च) २. चंद्रग्रहणाध्याया for (चन्द्रग्रहणाध्याय) ३. चतुर्योयं for (चतुर्थोयां)

५. 'इति' से 'अध्यायः' तक लुप्त हैं। अध्याय समाप्ति सूचक कोई और चिह्न भी विद्यमान नहीं ।

दृग्गणि[1]तैक्यं न[2] भवति यस्मात्पंचज्यया रविग्रहणे ।
यस्मा[3]द्यथा तदैक्यं तथा प्रवक्ष्यामि तिथ्यन्ते ॥ १ ॥
वित्रि[1]भलग्नसमेऽर्केन[4] लम्बनं तदधिकोनके भवति ।
तत्सं[3]क्रान्ति ज्योदक्[2] यदाक्षजीवा समा न तदा ॥ २ ॥
अवनतिरतोन्यथा भवति संभ[1]वेत्तदुदयैर्विलग्न[2]समं कृत्वा[5] ।
तदुदितघटिकातः[3] छंकु[4]स्तच्चरप्राणैः ॥ ३ ॥
त्रिज्याकृते[1] चतुर्गुणशंकुहताया[2] फलेन भक्तायाः ।
तात्कालिकार्कराशित्र[3]योनलग्नान्तरज्याया[4] ॥ ४ ॥

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१. (घ) १. दृग्दणितैक्यं (च) for (दृग्गणितैक्यं)
(ग) ३. तस्माद्यथा for (यस्माद्यथा)
(क) २. 'न' पद लुप्त है ।
३. तस्माद्यथा for (यस्माद्यथा)

२. (घ) १. वित्रिग्नसमे for (वित्रिभलग्नसमे)
२. द्योदक् (ग) ज्योदग (क) ज्यादक् for (ज्योदक्)
(ग) ३. तत्स्वक्रांति (क) तन् खक्रान्ति for (तत्संक्रान्ति)
(च) ४. र्क्केन for (ऽर्केन) ३ तत्सक्रांतिस्योदक् for (तत्संक्रान्तिज्योदक्)

३. (घ) १. स भवे तदुदयै (ग) संभवेतदुयै (क) संभवेतदुदयै for (संभवेत्तदुदयै)
२. विलग्न समं for (र्विलग्नसमं)
३. घटिकात्तछंकुस् (ग) घटिकास्त छंकु (क) घटिकास्तच्छंकुस् for (घटिकातः छंकुस्)
(क) ५. 'कृत्वा' यह पद पूर्वार्ध का अंतिम न होकर उत्तरार्ध का आरम्भिक है (च)

४. (घ) १. कृतेश्चतुर्गुण (ग) कृतेश्चतुर्गुणं १०६९२९०० for (कृते चतुर्गुणं)
२. हृताया (ग) हृतायाः (च) हृताया for (हृताया)
३. राशित्रं for (राशित्र)
४. लग्नांतरद्यायाः (च) for (लग्नांतरज्यायाः)
(क) १. कृतेः श्चतुर्गुण for (कृते चतुर्गुण)
(च) १. कृतेश्चतुर्गुण for (कृतेचतुर्गुण)

लम्बनघटिकालग्नात् तात्कालिकात्त्रिराश्यूनात् ।
ऋण (ऋणं) अधिके ऽर्के हीने धनमसकृत्पंच दृश्यन्ते ॥ ५ ॥
कर्ण गुणाद् व्यासार्द्धाद्वसुवेद ४८ विभाजिता फलविभक्ता ।
लम्बननाड्यो भास्करवित्रिभलग्नान्तरं वा ॥ ६ ॥
रविशशिपातगतिकला लम्बनघटिका गुणषष्ट्या ।
यदि लम्बनमृणमूना धनमधिकाः स्वफललिप्ताभिः ॥ ७ ॥
अक्षज्याया वित्रिभलग्नात्स्वक्रान्तिरुत्तरार्कस्य ।
इन्दोर्वा यद्यधिका न नतिः सौम्या ऽन्यथा याम्या ॥ ८ ॥

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५. (घ) १. लब्धं लंबन (ग) लब्धं लंबन् (च) for (लम्बन)
२. ऋणमधिके (ग) रुणमधिकेक्कं हीने (क) ऋणमधिकेऽक्कं हीने for (ऋणं अधिकेऽर्के हीने)
२. ससत्कृत्पंच (क) मसकृत्यं च for (मसकृत्पंच)
४. दश्यंते (क) दश्यन्ते (च) दश्यंते for (दृश्यंते)
(क) १. लब्धं लंबन for (लम्बन)
(च) ५. राश्रनात् for (राश्यूनात्) १ ऋणमधिकेर्के for ऋणं अधिकेऽर्के)

६. (घ) १. विभाजितात्पलविभक्ता (ग) विभाजितात्फलविभक्ता (क) (च) for (विभाजिता फलविभक्ता)
२. लंबतन्याड्यो for (लम्बननाड्यो)
३. वित्रिवजग्नांतर (ग) वित्रिलग्नांतर (क) बित्रिभलग्नांतर for वित्रिभल-ग्नांतरं)
४. घावा (ग) ज्यावा (क) ज्यावा for (वा)
(च) ४. लग्नांतरद्यावा for (लग्नांतरं वां)

७. (घ) १. गुणाद्धृता-गुणा हृता (ग) (क) गुणाहृता षष्ट्या for (गुणषष्ट्या)
(ग) २. शशिपातागति for (शशिपातगति)
३. स्वफललिप्तानिः for (स्वफललिप्ताभिः)
(च) १. गुणा हृताषष्ट्या for (गुणषष्ट्या)

८. (घ) १. अक्षय्याया (ग) अक्षछाया for (अक्षज्याया)
२. अवनतिः (ग) (क) ऽवनतिः for (ननतिः)
(क) ४. स्वाक्रान्ति for (स्वक्रान्ति)
(च) ३. वनतिः for (ननतिः)
५. अवग्रहचिह्न लुप्त

वित्रिभलग्नादुत्तरदक्षिण[1]विक्षेपहीनसंयुक्तम् ।
शंकुधनुरूत्तरायामधिकोनं दाक्षणावनतौ[2] ॥ ९ ॥
तज्ज्येंदु (तज्जेंदु) शंकुराद्यः सवितुः दृक्षेप[1] मंडले युक्त ।
अपमण्डलेन भानोश्चन्द्रस्य विमण्डलेन युते ॥ १० ॥
त्रिज्या वर्गावुनौ[1] स्वशंकुवर्गेण तत्पदे दृग्ज्ये ।
रविशशिमध्यगतिगुणे तिथिगुणितव्यासदलभक्त ॥ ११ ॥
४९०[3]५०[4] स्वछायागुणिते वा मध्यगति[1]तिथिगुणस्वकर्णहृते ।
फलयोर्दिक् याम्येतर[2]मवनतिरैक्यं दिगन्यत्वे ॥ १२ ॥
संयोगान्तरमवनतिशशांकविक्षेपयोः सामान्यदिशोः[1] ।
स्फुट[2]विक्षेपः शशिवत्[3] स्थित्यर्द्धं[4] विमर्द[5]दलनाडचः ॥ १३ ॥
प्राग्वल्लम्बनमसकृत्तिथ्यांतात्[1] स्थितिदलेन हीनयुतात् ।
अधिकोनं तन्मध्या ऋणयोरू[2]नाधिकं धनयोः ॥ १४ ॥

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९. (घ) १. दक्षण for (दक्षिण)
२. दक्षिणावनतो (ग) (क) दक्षिणावनतौ for (दाक्षणावनतौ)
(च) १. दक्षण for (दक्षिण) २ दक्षिणावनतो for (दाक्षणावनतो)
१०. (घ) १. दृक् (क) दृक्क्षेप for (दृक्षेप)
(च) १. दृ क्षेप for (दृक्षेप)
११. (घ) १. वर्गाव्रुनौ (ग) वर्गानूनौ (क) वर्गाबूनौ for (च) वर्ग्गावुनौ (वर्गावुनौ)
१२. (घ) १. गती (ग) (क) for (गति)
२. साम्येंतर (ग) साम्येतर (क) साम्येऽन्तर for (याम्येतर)
(ग) ३. यह संख्या इस प्रति में अंकित नहीं है।
४. स्वछया (क) तच्छाया for (स्वछाया)
१३. (घ) १. समान्यदिशोः (ग) (क) समान्यदिशोः (च) for (सामान्यदिशोः)
२. स्फुटिविक्षेपः for (स्फुट विक्षेपः)
३. शशिन for (शशिवत्)
(ग) ४. स्थित्यर्द्धे (क) for (स्थित्यर्द्धं)
(च) ३. शशिव for (शशिवत्)
५. विमर्द्द for (विमर्द)
१४. (घ) १. असकृत्तिथ्यंतात् (ग) (च) for (असकृत्तिथ्यांतात्)
२. मध्याद्दणयो (ग) (क) मध्याद्दणयो (च) for (मध्याऋणयो)

यद्यधिकं स्थित्यर्द्धं तदन्तरेणान्यथोनमृणमेकम् ।
अन्यद्धनं तदैक्येनाधिकमेवं[1] विमर्दार्द्धः[2] ॥ १५ ॥
स्फुटतिथ्यंता[4]ल्लम्बन[2]मसकृतस्थित्यर्ध[3]हीनयुक्ताद्वा ।
तत्स्फुटविक्षेपकृति[1]स्थित्यर्द्धोनयुततिथ्यन्ते ॥ १६ ॥
तत्स्पष्ट[3]तिथिच्छेदांतरे स्फुटे तिथि[1]दले विहीनयुतात् ।
स्वविमर्दार्द्धेना[5]ऽसकृदेवं स्पष्टो[2] विमर्दार्द्धे[4] ॥ १७ ॥
शशिवद्बाहुः[4] स्फुटविक्षेपकृतं[1] स्थितिदलेन संगुणिता[3] ।
स्पष्टः[6] स्थित्यर्धहतो[2] भवति भुजः पूर्ववच्छेषम्[4] ॥ १८ ॥

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१५. (घ) तदैक्येनाधिकमेवं (ग) (च) for (तदेक्येनाधिकमेवं)
(क) २. विमर्दार्द्धे (च) for (विमर्दार्द्धः)

१६. (घ) १. कृत (ग) कृतः (च) कृत for (कृति)
(ग) २. तालंबन for (ताल्लंबन)
३. मसकृत्स्थित्यर्द्ध for (मसकृतस्थित्यर्ध)
(क) यहाँ पूरा श्लोक अंकित नहीं। लिपिकार की भूल से। केवल अंकित है—
''स्फुटे तस्य ताल्ल तत युत तिथ्यंते'' ॥ १६ ॥
(च) ४. तिथांता for (तिथ्यंता)

१७. (घ) १. स्थिति (ग) (क) (च) for (तिथि)
२. स्पष्टे (ग) (क) (च) for (स्पष्टो)
(ग) ३. तत्स्फुट for (तत्स्पष्ट)
४. विमर्दार्द्धं for (विमर्दार्द्धे)
(च) ५. विमर्द्दार्द्धेनासक्तदेवं for (विमर्दार्द्धेनाऽसकृदेवं)

१८. (घ) १. कृतस्थितिर्दलेन for (कृतंस्थितिदलेन) (ग) कृतः (क) कृतः for (कृतं)
२. हृतो (ग) (क) (च) for (हतो)
(ग) ३. संगुणितः (च) for (संगुणिता)
४. पूर्ववछेषम् (क) पूर्ववत् शेषम् ॥ १८ ॥ for (पूर्ववच्छेषम्)
(क) ५. विसर्गलुप्त
६. विसर्गलुप्त
(च) १. कृतस्थिति for (कृतंस्थिति)
४. पूर्ववछेषम् for (पूर्ववच्छेषम्)

ग्रासात्कालः[2] प्राग्वत्[3]स्पष्टस्थितिदलगुणो सकृद्भुक्तः[4] ।
स्फुटविक्षेप[1]ऋत[5]स्थितिदलेन शोध्यः[6] स्थितिदलात्स्वात् ॥ १९ ॥
वलनादिशशिवदन्यत्[2] ग्रहणं तैक्ष्णाद्रवरनादेश्यम्[1] ।
द्वादशभागादूनं स्वच्छत्वात्षोडशादिदे[3] ॥ २० ॥
न स्फुटमार्यभटादिष्टर्क[1]ग्रहणं यतस्ततः[2] स्पष्टम् ।
शंकुज्यया कृतं लघु लघुतरमेवं रविग्रहणम्[3] ॥ २१ ॥
लग्नात्त्रिराशिहीना[1]दपक्रम[2]क्षांशयुतिविशेषोनात् ।
भतृतया[6] तज्जया[3] भक्ता त्रिज्यार्द्ध कृत्तिः[4] ३६७३२२५ फलेनहृता[5] ॥२२॥

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१९. (घ) १. विक्षेकृत (ग) विक्षेपकृतः for (विक्षेपऋत)
(ग) २. ग्रासात्कालः (क) ग्रासीत्कालः for (ग्रासात्कालः)
३. शशिवत् (क) स्पर्शवन् for (प्राग्वत्)
(क) ४. ऽसकृद्भुक्तः for (सकृद्भुक्तः)
५. कृत (च) for (ऋत)
६. सोध्यः for (शोध्यः)
७. स्यात् for (स्वात्)

२०. (घ) १. तैक्ष्ण्याद्रवेरनादेश्यम् (ग) (क) (च) for (तैक्ष्णाद्रवरनादेश्यम्)
(ग) २. वदन्यग्रहणम् (क) वदन्यद्ग्रहणम् for (वदन्यत् ग्रहणम्)
३. दिदोः (क) for (दिदे)

२१. (घ) १. भटादिष्वर्क (ग) for (भटादिष्टर्क)
(ग) २. तत्स्पष्टम् (क) ततः स्पृष्टम् for (ततः स्पष्टम्)
(क) ३. रवेर्ग्रहणम् for (रविग्रहणम्)
(च) १. भटादिष्वर्क्क ग्रहणं for (भटादिष्वर्कग्रहणं)

२२. (घ) १. हीदप for (हीनादप)
२. क्रमाक्षांश (ग) (क) (च) for (क्रमक्षांश)
३. तज्या for (तज्जया) (ग) ज्याछेदस्त्रिज्या (क) ज्ज्याछेदस्त्रिज्या for (भतृतया तज्जया)
४. त्रिज्यार्धकृतिः (ग) द्धकृते २६७३२२५ (क) कृतेः for (त्रिज्यार्द्ध कृतिः)
५. हृता (क) for (हृता)
(ग) ६. भत्रितया (क) for (भतृतया)
(च) ६. भत्रीतया for (भतृतया) ३ तज्या for (तज्जया)
४. त्रिज्यार्द्धकृतिः for (त्रिज्यार्द्धकृत्तिः)

त्रित्रिभलग्नार्कांतरजीवा[3] घटिकादिलम्बनं लब्धम् ।
वित्रिभलग्नापक्रमविक्षेपा[4]क्षांशयुतिवियुति[2] (ते) ॥ २३ ॥
जीवा शशांकभास्करमध्यमभु[1]क्तांतरेण संगु[3]णिता ।
पंचदश-भिर्गु[2]णितं या विभाजिता त्रिज्यया वनति[4] ॥ २४ ॥
४६०५० पूर्ववदन्यस्पष्टं[1] ब्रह्मोक्त[3]स्पष्टसूर्यशशिपातैः ।
नार्यभटादिभिरुक्तै[5] र्या[2] तो स्फुटास्ते[4] ततो स्पष्टम्[6] ॥ २५ ॥

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२३. (घ) १. भितृ लग्नार्कांतर (ग) वित्रिभ लग्नार्कांतरे for (त्रित्रिभलग्नार्कांतर)
२. वियुते (ग) (च) for (वियुति (ते))

(ग) ३. जीवाद्य for (जीवाघ)
४. विक्षपाक्षांश for (विक्षेपाक्षांश)

(क) यहाँ श्लोक की प्रथम पंक्ति लिपिकार लिखना भूल गया। दूसरी है—
"वित्तिभलग्नापक्रमविक्षे पक्षांशयुतिवियुतेः ॥ २३ ॥"

(च) १. वित्रिभलग्नार्क्कांतर for (त्रित्रिभलग्नार्कांतर)

२४. (घ) १. मध्यमभुक्त्यंतरेण (ग) (क) (च) for (मध्यभुक्तांतरेण)
२. गुणितं (ग) र्गुणितया (क) for (र्गुणितं)

(ग) ३. संगणिता for (संगुणिता)
४. वनतिः (क) for (वनति)

२५. (घ) १. पूर्ववदन्यत्स्पष्टं (क) (च) for (पूर्ववदन्यस्पष्टं)
२. यतो (ग) यतोऽस्फुटा (क) यतोऽस्फुटस्ते for (र्यातो स्फुटास्ते)

(ग) ३. ब्रह्मोक्तं for (ब्रह्मोक्त)
४. स्तैंततोऽस्पष्टाम् (क) स्तेततोऽस्पष्टम् for (स्तेततो स्पष्टम्)

(क) ५. रुक्तेक्तै for (रुक्तै)

(च) २. र्यतो for (र्यातो)
६. वि०—यहां चिह्न लगाकर ऊपर के रिक्तोपान्त पर निम्नलिखित श्लोक—
किसी अन्य हाथ से लिखा हुआ विद्यमान है—
"अंगुलमात्र विरते रक्तः शशिमंडले भवेत्कर्णः ।
भानोस्तु पुन कुंदमो वर्णं सर्वत्र निर्दिष्टः ॥"

इष्टग्रासविमर्दस्थित्यर्द्धा वनति लम्बा[1] नाद्येषु ।
आर्या षड्विंशत्यर्क[2]ग्रहण[3]पंचमोऽध्यायः ॥ २६ ॥
इति ब्रह्मगुप्ते[4] पंचमोऽध्यायः ॥

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२६. (घ) २. लंबनाद्येषु (ग) for (लम्बानाद्येषु)

२. षड्विंशत्याऽर्क (ग) (च) for (षड्विंशत्यर्क)

३. ग्रहणं (ग) for (ग्रहण)

(ग) ४. 'इति' से 'अध्यायः' तक इस प्रति में लुप्त। केवल समाप्ति सूचक छः, छः, छः, अंकित है

यह श्लोक इस प्रति में नहीं है।

(च) १. लंबनाद्यु for (लंबनाद्येषु)

३. 'इति' से 'अध्यायः' तक लुप्त है।

ग्रहाभास्करांतरैः[1] प्राक् पश्चादर्कग्रहान्तरैर्यस्मात्[3] ।
स्वांशैर्[4] दृश्या[5] दृश्यास्तस्माद्वक्ष्ये[2] तदानयनम् ॥ १ ॥
प्रागूनभुक्तिरूनो दृश्ये दृश्यो[3] रविरधिकभुक्तिः[1] ।
पश्चाद्दृश्योऽधिक[4]गतिरधिको दृश्यो[5] ग्रहो ऽल्पगतिः[2] ॥ २ ॥
विक्षेपसत्रिराशिक्रान्तिवधो व्यासदलहृतो[3] लिप्ताः ।
शोध्यास्तयोः समदृशो[4]र्यदन्यदिशो[1] ग्रहे[2] क्षेपाः[5] ॥ ३ ॥

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१. (घ) १. ग्रहभास्करान्तरैः (ग) ग्रहभास्करांतरैः for (ग्रहाभास्करांतरैः)

(ग) २. वक्षे for (वक्ष्ये)

(क) यह श्लोक उपलब्ध नहीं है।

(च) १. ग्रहभास्करांतरैः for (ग्रहाभास्करांतरैः) ३ प्राक्पश्चादर्क्कग्रहांतरै for (प्राक् पश्चादर्कग्रहांतरै)

४. स्वाशै for (स्वांशै) ५. दृश्या for (दृंश्या)

२. (घ) १. रवेरधिकभुक्तिः (च) for (रविरधिकभुक्तिः)

२. गति (च) for (गतिः)

(ग) ३. दृश्योश्यो for (दृश्येदृश्यो)

४. पश्चाद्रिश्योरधिक for (पश्चाद्दृश्योऽधिक)

(क) यह श्लोक उपलब्ध नहीं है।

(च) ५. दृंश्यो for (दृश्यो)

३. (घ) १. र्यद्यन्यदिशो (ग) (च) for (र्यदन्यदिशो)

२. ग्रंहे (ग) for (ग्रहे)

(ग) ३. हृतो for (ह्रतो)

४. समर्द्दिशो (च) for (समदृशो)

(क) यह श्लोक उपलब्ध नहीं है।

(च) ५. क्षेप्याः for (क्षेपाः)

विषुवच्छाया[1] गुणिताद्विक्षेपा [4]द्वादशो[5]द्धृता सोम्यात्[2] ।
फलमृणधनं धनर्णं[6] याम्यादुदयास्तमन्यलग्ने[3] ॥ ४ ॥
प्रागून[3]माद्यमधिकं पश्चा[4]ल्लग्नाद्ग्रहोदयोस्तमय[5]षड्भयुतम् ।
अन्यदुदयैः[1] घटिकाः कृत्वा[2] नमधिकं समम् ॥ ५ ॥

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४. (घ) १. विषुवछाया (ग) (च) for (विषुवच्छाया)
२. सौम्यात् (ग) त्सौम्यात् (क) for (सोम्यात्)
३. उदयास्तमयलग्ने, (ग) उदयास्तमलग्ने for (उदयास्तमन्यलग्ने)

(क) ०. विक्षेपात् । तद्वादशो for (विक्षेपा द्वादशो)
५. हृतात् for (द्धृता)
६. धनंर्ण for (धनर्णं)
३. उदयास्तमयलग्नौ for (उदयास्तमन्यलग्ने)

(च) २. सौम्यात् for (सोम्यात्)
३. याम्यादुदयास्तमयलग्ने for (याम्यादुदयास्तमन्यलग्ने)

५. (घ) १. उदयैर्घटिकाः (क) उदयैर्घटिकाः for (उदयैः घटिकाः)
२. कृत्वोनमधिक (ग) (क) कृत्वोनमधिक for (कृत्वानमधिकं समं)

(ग) ३. प्रागूना for (प्रागून)
४. लग्नात्पश्चाद्ग्रहोदयोस्तमयम् for (पश्चाल्लग्नाद्ग्रहोदयोस्तमय)
५. षट्कयुतमन्यदुदयैर्घटिकाः (वि० दूसरी पंक्ति का आरम्भ) for (षड्भयुतम्—द्वि० पं०—अन्यदुदयैर्घटिकाः)

(क) ४. पश्चाल् लग्नात् ग्रहोदयोस्तमयः for (पश्चाल्लग्नाद्ग्रहोदयास्तमय)
५. 'षड्भसंयुतं' for (षड्भयुतम्) दूसरी पंक्ति का आरम्भ

(च) ५ षड्भूयुतं for (षड्भयुतम्)
१. अन्यदुदयैर्घटिकाः for (अन्यदुदयैः घटिकाः)
२. कृत्वोनमधिकसमं for (कृत्वा नमधिकं समं)

द्वादशभिः शि[1]तांशुसितजीवज्ञ[6]शनिभूमिजा नवभिः ।
द्यु[3]त्तर वृद्धयैरंतरघटिका षड्[7]गुणिता क[4]लांशैः ॥ ६ ॥
१[2]२।६।११।१५।१७ दृश्यादृ[3]श्यायुति[8]वद्ग्रहार्क [5]भु[6]क्तचंतरैक्यलब्धदिनैः ।
[7]ऊनाधिकलि[8]प्ताभ्यः प्राग्वत् तात्कालिकै[1]रसकृत ॥ ७ ॥
प्रतिदिनमुदयास्तमयाव[4]सकृत् ता[1]त्कालिक ग्र[6]ह विलग्नैः ।
सूर्यास्तमयोद[5]यिकैः शीतां[2]शौ पौर्णि[3]मास्यन्ते ॥ ८ ॥

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६. (घ) १. शीतांशुः (क) (ग) शीतांशुः for (शितांशु)
४. भूमिजातवभिः for (भूमिजानवभिः)
३. द्वयु्त्तरवृद्धे (ग) द्वयूत्तरवृद्धि (क) द्वयु्त्तरवृद्धै for (द्युत्तरवृद्धयै)
४. कालांशैः (ग) (क) for (कलांशैः)
६. निभूमिजा नवभिः ।६।।११।१३।१५।१७।। for (शनिभूमिजा नवभिः)
(क) ७. षड्गुणित for (षड्गुणिता)
(च) १. शीतांशु for (शितांशु) ३ द्वयु्त्तरद्वृद्धैरंतर for (द्युत्तरवृद्धयैरंतर)
४. कालाशैः for (कलांशैः)
७. (घ) १. रसकृतः (ग) रसकृत् (क) रसकृत् for (रसकृत)
(ग) २. यह संख्याएं पूर्वश्लोक के पूर्वार्द्ध के पश्चात् अंकित हैं ।
३. दृश्याग्रहयुति (क) दृश्यादृश्यैर्युति for (दृश्यादृश्यायुति)
(क) ४. ग्राहार्क for (ग्रहार्क)
५. ६. भवति for (लब्धदिनैः)
७. नैकेनाधिक for (ऊनाधिक)
८. लिप्ताभ्यां for (लिप्ताभ्यः)
(च) ४. ग्रहार्क्क for (ग्रहार्क) ७ उनाधिक for (ऊनाधिक)
१. रसकृत् for (रसकृत)
८. (च) १. तालिक for (तात्कालिक)
२. शीतांशो (ग) शीतांशोः (क) for (शीतांशौ)
३. पौर्णिम्यास्यां च (ग) (क) पूर्णिमास्या च (पौर्णिमास्यन्ते)
(ग) ४. वसक्र (क) च सकृत् for (वसकृत्)
५. दयकैः (क) दयकैः for (दयिकैः)
(क) ६. ग्रहाविलग्नैः for (ग्रहविलग्नैः)
४. वसकृत्तात्कालिक for (वसकृत् तात्कालिक)
३. पोर्णिमास्यांत for (पौर्णिमास्यन्ते)

उदयास्तमयावदिदोः[1] कलांशैरर्कसंमिते कार्यम् ।
हीनत्वं त्वधिकत्वंतरे योग काल स्यात् ॥ ६ ॥
उदयास्तविधौ विवद्बुध्य शीघ्रादाप्तफल युतोनज्ञः[1] ।
अस्मद्गुरू विहीन[2] समद्ग्र[3]····भागेन ॥ १० ॥
माना[1]ऽल्पत्वात्पश्चादुदयो[7]स्तमयः[8] सितस्य दशभि[5] प्राक् ।
पश्चान्मानं[2] हत्वा दष्टमयो[3]स्ताभि[4]रुदयः[6] प्राक् ॥ ११ ॥[9]

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६. (क) यह श्लोक मूल पाठ में नहीं है । (ग)

(क) यह श्लोक उपलब्ध नहीं है ।

(च) वि० यहाँ यह श्लोक निम्न उपान्त पर अन्यहस्तलेख में दिया गया है—

१. उदयस्तमयवदिदोः for (उदयास्तमयावदिदोः)

१०. (घ) यह श्लोक मूल पाठ में नहीं है । (ग) (क)

(च) वि० यह श्लोक २५b पृष्ट पर निम्नोपात पर अग्यपस्त से दिया हुआ है !

१. नोज्ञः for (नज्ञः) २ विहिनः for (विहीन)

३. ससम for (समद्ग्र)

११. (घ) इसका संख्याक्रम ६ है (ग)

१. माता for (माना)
२. मानमहत्वा (क) (क) for (मानं हत्वा)
३. दस्तमयो (ग) (क) for (दष्टमयो)
४. ष्टाभि (ग) (क) for (स्ताभि)

(ग) ५. दशभिः (क) (च) for (दशभि)
६. रुदय (क) for (रुदयः प्राक्)

(क) ७. दुदयो for (पश्चादुदयो)
८. स्तमयो for (स्तमयः)

(च) २. मानमहत्त्वादस्तमयो for (मानं हत्वादष्टमयो)
४. ष्टाभिरुदयः for (स्ताभिरुदयः)
६. क्रमसंख्या '६' है !

ज्ञस्यैवं[1] मनुसूर्ये[2] पठितैः[3] कुजजीवपुत्राणाम् ।
उदय[4] प्राग्[5] ऽस्तमयो मानसमत्वाद्भवति[6] पश्चात् ।। १२[7] ।।
आर्यभटः[6] क्षेत्रांशैर्दृश्यान्यदुक्तवास्तदसत्[4 7 1] ।
दृग्गणितैक्यं[5] विसंवाहा दृग्गणितैक्यं[8] स्वकालाशैः[2] ।। १३ ।।

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१२. (घ) इसका संख्याक्रम १० है (ग)

१. ज्ञास्येवं (ग) ज्ञस्यैव (क) ज्ञास्यवं for (ज्ञस्यैवं)
२. पठितै (क) पवितै for (पठितैः)
३. जीवसूर्यपुत्राणाम् (वा) (क) जीवसूर्यपुत्राणां for (जीवपुत्राणाम्)
४. उदयः (ग) (च) for (उदय)
५. प्रागस्तमयो (ग) प्रागस्तमयौ (क) प्रागस्तमयो for (प्राग्ऽस्तमयो)

(ग) ६. माहनमहत्त्वाद्भवति पश्चात् for (मानसमत्त्वाद्भवति पश्चात्)

(क) ७. ।। १० ।। (च) for (।। १२ ।।)

(च) २. पठितै for (पठितैः) ३ + सूर्य +
५. प्रागस्तमयो for (प्राग् ऽस्तमयो)

१३. (घ) इसकी क्रमसंख्या ११ है (ग)

१. दुक्तवांस्तदसत् (ग) (च) for (दुक्तवास्तदमत्)
२. स्वकलांशैः । ११ । (ग) स्वकाल्पांशैः for (स्वकालाशैः)
३. रेखांकित पाठ मूल में नहीं है ।

(ग) ४. दृश्याद्ययुक्त for (दृश्यान्ययुक्त)
५. दृग्गणित विसंवादा (क) दृग्जगणितं विसंविवादात् for (दृग्गणितैक्यं विसंवाहा)

(क) ६. आर्यभट्ट for (आर्यभटः)
७. अदुक्तवान् तदसत् for (अदुक्तवास्तदसत्)
८. सूपवित्तकालाशै र्दृग्जगणितैक्यं भवति ।। ११ ।। for (विसंवाहा दृग्गणितैक्यं स्वकालाशैः ।। १३ ।।)

(च) २. स्वकालांशैः for (स्वकालाशैः)
८. द्रग्गणितैक्यं for (दृग्गणितैक्यं)

दृग्लग्न[१] दृष्टिभाग ग्रहोदयास्तमयनाडिकाद्येषु[४] ।
मयाध्यायः[२][६] चतुर्दश[३]भिरार्याभिः ॥ १४ ॥
इति[५] ब्रह्मगुप्ते षष्ठोऽध्यायः ।

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१४. (घ) इसकी क्रमसंसंख्या १२ है (ग)

१. दृल्लग्न दृष्टिभाग (ग) दृग्लग्नद्रिष्टिभाग for (दृग्गलग्न दृष्टिभाग)
२. उदयास्तमयाध्यायः षष्ठो (ग) (क) उदयास्तमयो for (मयाध्यायः)
३. द्वादशभिरार्याभि । द्वादशभिरार्याभिः । for (चतुर्दशभिरार्याभिः)
५. 'इति' से 'अध्यायः' तक मूल प्रति में नहीं है । केवल समाप्तिसूचक "छः" चिन्ह है ।

(क) ६. ऽध्यायाषष्ठो द्वादशाभिरा र्याभिः for (अध्यायः चतुर्दशभि रार्याभिः ॥१४॥)

(च) २. उदयास्तमयाध्यायः षष्ठो for (मयाध्यायः)
३. द्वादशभि for (चतुर्दशभि)
४. 'इति' से 'अध्यायः' तक लुप्त है ।

सितवृद्धि[६] हानिर्वा यदि शापाज्जायते[१] कथम[५] गणितात्[२] ।
उपरि खेरिन्दुश्चेदंर्धांगर्धं[३] सदा शुक्लां[४] ॥ १ ॥
रविद्रष्टं[१] सितमर्द्धं[२] कृष्णमदृष्टं[३] यथा तपस्थस्य[५] ।
कुम्भस्य तथासन्नं खेरर्धंस्थस्य[४] चन्द्रस्य ॥ २ ॥

(घ) १. (ग) शापात् ज्ञायते for (शापाज्जायते)

५. कथं (ग) 'अनंकित' है for (कथम)

३. दर्वागर्धं (ग) for (दंर्धांगर्धं)

४. शुक्लम् (ग) for (शुक्लां)

(ग) २. गणितान् for (गणितात्)

(च) ५. कथं for (कथम)

३. चेदर्वागर्द्धं for (चेदंर्धांगर्धं)

(क) १. २. गणितान् for (गणितान्)

३. दर्वांगर्द्धं for (दंर्धांगर्धं)

४. शुक्लं for (शुक्लां)

६. वृद्धिर्हानि for (वृद्धिहानि)

२. (घ) १. दृष्टं (ग) द्रिष्टं for (द्रष्टं)

४. रघस्थस्य (ग) for (रर्धंस्थस्य)

(ग) ३. मकृष्णं for (मदृष्टं)

५. तस्य for (थस्य)

(च) १. दृष्टं for (द्रष्टं)

(क) १. दृष्टं for (द्रष्टं) २. शितमर्द्धं (सितमर्द्धं) ३. दृश्यं for (दृष्टं) ४. रघः for (रर्धं)

सिममुण्णतं[1] यतोर्कं[2] सितासितं शुक्ल[6]कृष्णपक्षांते ।
अर्धागद्धं[3] पश्चाद्गणिता[4] छृंगोन्नतिस्तस्मात्[5] ॥ ३ ॥
रवि[1]चन्द्रपात[4] लग्नैं[2] स्वक्रान्त्युदयास्तलग्नगत[5]शेषाः ।
घटिकाः[6] स्वचरार्द्धस्तौ[3] स्वेष्ट[7]कालिकैः शीतगो[8] कृत्वा ॥ ४ ॥

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३. (घ) १. मुन्नतं (ग) (च) for (मुण्णतं)

२. यतोर्कः (ग) (च) for (यतोर्क)

६. सुक्ल for (शुक्ल)

३. अर्वागद्धं (ग) (च) for (अर्धागद्धं)

४. यस्माद्गणिता (ग) for (पश्चाद्गणिता)

५. छृंयोन्नतिस्तस्मात् (ग) for (छृंगोन्नतिस्तस्मात्)

(क) १. मुन्नतं for (मुण्णतं) २. यतोऽर्कः for (यतोर्क) ३. अर्वागद्धं for (अर्धागद्धं)

४. यस्मान् गणितान् for (पश्चाद्गणिता) ५. शृंगोन्नति तस्मान् for (छृंगोन्नतिस्तस्मात्)

४. (घ) २. लग्नैः (च) for (लग्नैं)

३. स्वचरास्त for (स्वचरार्द्धस्तौ)

(ग) ४. पाता for (पात)

५. गतः for (गत)

६. घटिका स्वचरास्तं for (घटिकाः स्वचरार्द्धस्तौ)

७. श्वेष्ट for (स्वेष्ट)

८. शीतगोः (च) for (शीतगो)

(क) १. रवि चन्द्रपातलग्नैः शृंङ्गोन्नतिकालिकैं स्वक्रान्ति उदयस्तलग्नगतशेषघटिकाः।
स्वचरांशून कृत्वा प्रति घटिका शृङ्गोन्नति गणनीयः ॥

for

(रविचन्द्रपातलग्नै स्वक्रान्त्युदयास्तलग्नगतशेषाः ।

घटिकाः स्वचरार्द्धस्तौ स्वेस्टकालिकैः शीतगो कृत्वा ॥४॥)

[१]शशिविक्षेपाक्रमधनुषो[६] योगान्तरं[७] समान्य[२]दिशोः ।
[३]सज्ज्येद्वयक्रम[४]ज्या स्वाहोरात्रा[५]द्यतो रविवत् ॥ ५ ॥
स्वक्रान्तिज्ये[१] त्रिज्यागुणे हते[२] लम्बकेन[३] रविशशिनोः[६] ।
[७]अग्रे पृथक् स्वशंकुतल तुल्ययुक्ते[४] विदिक्[५] वियुते ॥ ६ ॥

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५. (घ) ६. धनुखोर्योगाँत for (धनुषोयोगांत)

३. तज्येंद्वपक्रमय्या (ग) तज्येंद्वपक्रमज्या for (सज्ज्येद्वयक्रमज्या)

(ग) १. विक्षेपापक्रम for (विक्षेपाक्रम)

७. योंगान्तरं for (योगान्तरं)

(च) ६. धनुरवोर्योगांतरं for (धनुषो योगांतरं)

३. तज्येंद्वपक्रमज्या for (सज्ज्येद्वयक्रमज्या)

(क) १. विक्षेपराय्यपक्रम for (शशिविक्षेपाक्रम) २. सभाना for (समान्य)

३. तज्ज्ये for (सज्ज्ये) ४. क्रमज्यात् for (क्रमज्या) ५. यातौ for (यतो)

६. (घ) २. हृते (च) for (हते)

६. शनिनोः for (शशिनोः) (च)

७. अग्रें for (अग्रे)

(ग) ४. युते for (युक्ते)

५. न्यदिग्वियुते for (विदिक् विद्युते)

(क) १. ज्योतिज्ये for (क्रान्तिज्ये) २. वृते for (हते) ३. लावकेन for (लम्बकेंन)

४. युते for (युक्ते) ५. विदिम् for (विदिक्)

पृथगन्तरं[१] संयोगौ भुजौ[८] युतोर्का[२]छशी[३] समान्यदिशो[४] ।
दिग्ज्या[५] वर्गात्स्वात्[७] स्वपृथक्स्थं[६] वर्गं विशोध्य[९] पदे ॥ ७ ॥
वियुतसहिते[१] रविन्द्वो[६]रेकान्यकपालसंस्कृतयोराद्य[२] ।
रविशशिदृक्[३] शंक्वन्तर[७]मन्यो[४]ऽदृक् दृश्यशंक्वैक्यम्[५] ॥ ८ ॥

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७. (घ) १. पृथगंतर (ग) (च) for (पृथगन्तरं)
३. च्छसी (च) for (छशी)
४. समान्यदिशो: (ग) (च) for (समान्यदिशो)
५. दृग्ज्या (ग) दृक्ज्या वर्ग्रात् for (दिग्ज्यावर्गात्)
७. स्वात्स्वं (ग) स्वात्स्वपृथक् स्थवर्ग्र for (स्वपृथक्स्थंवर्ग)

(ग) ८. भुजौ for (भुजौ)
९. विशोध्यशेषपदे for (विशोध्यपदे)

(च) २. युतोऽर्क्का for (युतोर्का) ५. दृग्ज्या for (दिग्ज्या)
७. स्वात्स्वं for (स्वात्स्व) ६. पृथक् स्वर्ग for (पृथकस्थं वर्ग)

(क) १. पृथगंतर for (पृथगन्तरं) २. युतोऽर्कात् for (युतोर्का)
३. शशी for (छशी)
४. सामान्य दिशो: for (समान्यदिशो) ५. दृग्ज्यावर्ग्रात् स्वंस्वं for (दिग्ज्या-वर्गात्स्वात् स्व) ६. पृथक् स्ववर्ग्र for (पृथकस्थंवर्ग)

८. (घ) ६. रवींद्वो (ग) (च) for (रविन्द्वो)
२. संस्थयोराद्य:(ग) (च) for (संस्कृतयोराद्य:)
७. शक्वंवर (ग) शंक्वंतर for (शंक्वन्तर)
४. दृग (ग) दृश्यशंक्वैक्यम् for (दृश्यशंक्वैक्यम्)

(च) ४. दृग् for (ऽदृक्)

(क) १. सहितै for (सहिते) २. संस्थयोराद्य: for (संस्कृतयोराद्य:)
३. वृक् for (दृक्)
४. ऽदृक for (ऽदृक्) ५. शङ्क्वैक्यम् for (शंक्वैक्यम्)

[1]आद्यन्तवर्गयोगान्मूलं [2]पूर्वापरात् [4]भुजात् कोटिः ।
भुजकोटिकृतियुतिपदं [5]तिर्यक्कर्णस्य [3]चन्द्राग्र ॥ ९ ॥
एवं [1]तावाद्यावन्यदयो[2]राद्यन्तयो [3]शशिन्यर्कः ।
रविरर्द्धचक्र[4]युक्त कल्पो [5]द्वितृतयोरर्कः ॥ १० ॥
[7]व्यकन्दुदल[1]भुजाशाः [2]शशिमानगुणाः शितं [3]नवतिभक्ताः ।
[5]द्विगुणांशो क्रमजीवा[4]द्यावन्नवतिरंशाः ॥ ११ ॥

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९. (घ) १. आद्यान्यवर्ग (ग) आद्यान्यवर्ग्र for (आद्यन्तवर्ग)
२. पूर्वापरा (ग) for (पूर्वापरात्)
३. चन्द्रोग्र (च) for (चन्द्राग्र)
(ग) ४. भुजाः for (भुजात्)
५. तिर्यक्कर्णोस्य (च) for (तिर्यक्कर्णस्य)
(च) १. आद्यांत्य for (आद्यन्त) २. पूर्वापरा for (पूर्वापरात्)
(क) १. आज्याल्प for (आद्यन्त) २. पूर्वोपराभुजाकोटि for (पूर्वापरात् भुजात् कोटिः)

१०. (घ) १. तावाद्यावत्पदयो (ग) तावद्यावत्पदयो for (तावाद्यावन्यदयो)
३. शशीव्यर्क्कः (ग) (च) for (शशिन्यर्कः)
५. द्वितृतीययोरर्कः (ग) for (द्वितृतयोरर्कः)
(च) १. तावाद्यावत्पदयो for (तावाद्यावन्पदयो)
५. द्वित्रीतीययोरर्क्कः for (द्वितृतयोरर्कः)
(क) १. तावद्यावत्यक्षरयो for (तावाद्यावन्यदयो) २. राज्यतयो for (राद्यन्तयो)
३. शशीज्यर्क्क for (शशिन्यर्कः) ४. युक्तः for (युक्त) (ग) युक्तः ६ कलो for (युक्तकल्पो)
५. द्वितृतीयोरर्कः for (द्वितृतयोरर्कः)

११. (घ) १. भुजांशाः (ग) (च) for (भुजाशाः)
३. नवतिभक्ता (च) for (नवतिभक्ताः)
५. द्विगुणांशोत्क्रमजीवा (च) for (द्विगुणांशो क्रमजीवा)
४. तावाद्यावन्नवतिरंशाः (ग) तावद्यावन्नवतिरंशाः for (द्यावन्नवतिरंशाः)
(घ) ६. सितं for (शितं)
(च) ७. व्यक्केंदु for (व्यकेंदु) ३ नवतिभक्ता for (नवतिभक्ताः)
(क) १. भुजांशाः for (भुजाशा) २. शशिमानागुणासितं for (शशिमानगुणाःशितं)
३. भवति for (नवति) ४. जीवातावद् यावन्नवतिरशाः for (जीवाद्यावन्नवतिरंशाः)

नवतेरधिकांशाना क्रमज्यया संयुतो क्रमत्रिज्या ।
चन्द्रप्रमाणगुणिता द्विगुणा व्यासार्द्ध भक्तान्यत् ॥ १२ ॥ ६५ । ४०
प्रथमं शुक्लं रात्रौ दिवसेन्यसंध्ययोस्तदैक्यार्धम् ।
वर्णोज्यासवदिंदावसितस्य सितं श्रवणं गत्या ॥ १३ ॥
शशिमानपादवर्गो नामार्द्धं सितांतरार्द्धं भक्तयुतः ।
परिलेखसूत्रमध्ये शुक्लेर्द्धब्दैव परिलेखः ॥ १४ ॥

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१२. (घ) ३. रधिकांशा: नां (ग) रधिकांशानां for (रधिकांशाना)
२. संयुतोत्क्रम (ग) संयुतोत्क्रमे (च) for (संयुतोक्रम)
४. द्विगुण for (द्विगुणा)
(ग) ५. ६५४० for (६५।४०)
(च) ३. रधिकांशा: नां for (रधिकांशानां)
(क) नचते रविकांशानां for (नवतेरधिकांशाना) २. क्त्ुम for (क्रम)
१३. (घ) २. दिन्य for (दिवसेन्य)
३. वर्णोग्रास for (वर्णोज्यास)
४. श्रवण (च) for (श्रवणं)
(ग) ५. कर्णेन चन्द्रबिंबे शेषस्य ग्रासवद्वर्ण: for (वर्णो ज्यासवदिंदावसितस्य)
(च) ६. तदैक्यार्द्ध for (तदैक्यार्धम्)
(क) १. शुक्त (शुक्लं) for (शुक्लं) २ दिवसेन्यत् for (दिवसेन्य)
३. वर्णोग्रासवर्दिदावसितेस्य for (वर्गोज्यासवर्दिदासितस्य) ४. श्रवण for (श्रवणं)
१४. (घ) ४. परिलेख द्व शुल्केर्द्धाघेव (ग) परिलेखसूत्रमर्द्धे शुल्केर्द्ध ज्यैव for (परिलेख-सूत्रमध्ये शुक्लेर्द्धब्दैव)
३. शुल्केर्द्ध ज्येव for (शुल्केर्द्धब्दैव)
५. परिलेष: (च) for (परिलेख:)
(ग) २. पादवर्ज्योगानार्द्ध for (पादवर्गोनामार्द्ध)
६. वरार्द्ध for (तरार्द्ध)
७. भुक्तयुत: for (भक्तयुत:)
(च) ४. सूत्रमद्धेय for (सूत्रमध्ये)
३. शुक्लेद्वेष्टैव for (शुक्लेर्द्धब्दैव) ५ परिलेष: for (परिलेख:)
(क) १. शैंशमान for (शशिमान) २. पाक्ष्वर्गोमानार्द्ध for (पादवर्गोनामार्द्ध)
३. शुक्लेर्द्धज्येव for (शुक्लेर्द्धब्दैव)

त्रिप्रश्नोत्तया[५] शंकोः[१] पूर्वापरतो निधाय[४] दिग्मध्ये ।
छायाग्रं[३] छायाग्रछंकुंग्र[२] दीर्घसूत्रवशात् ॥ १५ ॥
कृत्वा विंशा[१]द्वितयं दृगुद्धृतं[२] पृथग्मुच्चरत[३]मन्यत् ।
प्रथमाग्रस्थितदृष्ट्या[५] द्वितीयवंशाग्रगं[४] चन्द्रम्[६] ॥ १६ ॥

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१५. (घ) ३. छायाग्रा (ग) छायाग्रात् for (छायाग्र)
२. छंक्वग्र (क) शक्वग्रग for (छंकुंग्र)

(ग) १. शंकुं for (शंकोः)
४. नधाय for (निधाय)

(च) ५. त्रीप्रश्न्योत्त्या for (त्रिप्रश्नोत्त्या)
२. छंकुग्र for (छंकुंग्र)

(क) १. शंकुं for (शंकोः) २. स्थूंक्कग्रगत for (छंकुंग्र)

(ग) अवर्केंदुदलभुजांशार्द्धं ज्याकर्णो द्विगुणिता भुजस्य कृति ।
प्रोह्य पदं·········भुजाग्रचंद्रांतरं कोटिः ॥ १६ ॥
यह श्लोक 'ग' में अतिरिक्त पाया गया है ।

१६. (घ) ३. प्रथम्नुच्चतर for (पृथग्मुच्चरत)
४. वंशागं for (वंशाग्रगं)

(ग) १. वंश for (विंशा)
२. दृगुछृतम् for (दृगुद्धृतं)
५. द्रिष्ट्या for (दृष्ट्या)
६. चन्द्रे for (चन्द्रम्)
(वि० इसकी क्रमसंख्या १८ है)

(च) ३. प्रथममुच्चरतमन्यत् for (पृथग्मुच्चरतमन्यत्)

(क) १. वंश for (विंशा) (ग) दृगुछितं (ग) for (दृगुद्धृतं) ३. प्रथममुच्चतरमन्यत् for (पृथग्मुच्चरतमन्यत्)

ग्रहणं ग्रहयोगं[2] वा विस्मय[4]करणाय दर्शयेद् गणकः ।
लोकस्य नरपतेर्वा दुष्करमन्यैर्गणितविद्भिः[3] ॥ १७ ॥
इति[3] वाहुकर्णकोटि[1]स्फुटसितपरिलेख[4]सूत्रकरणेषु ।
आर्याष्टादश चन्द्रशृंगोन्नतिरिह सप्तमो[5] ऽध्यायः ॥ १८ ॥
इति[6] श्रीब्रह्मगुप्ते सप्तमोऽध्यायः

(ग) लब्धेवं वानतयोः पूर्वापरयो खेस···चक्रात् ।
अग्रार्क्केंद्वोः शुक्लं पश्चाच्छुक्ले सिते पूर्वात् ॥ १७ ॥
यह श्लोक 'ग' में अतिरिक्त पाया गया है ।

१७. (घ) २. ग्रहयो योगं for (ग्रहयोगं)

३. गणिविद्भिः (ग) गणितषड्भिः for (गणितविद्भिः)

(ग) इसकी क्रमसंख्या १९ है ।

४. विश्मय for (विस्मय)

(क) १. नरपतेर्दुष्कर for (नरपतेर्वादुष्कर)

१८. (ग) वि०—इसकी क्रमसंख्या २० है ।

३. इतिपादकोटिकर्णः for (इतिवाहुकर्णकोटि)

४. परिलेष for (परिलेख)

२. विंशतिरार्या शृंगोन्नतिरिंदोः सप्तमोध्यायः for (आर्याष्टादशचन्द्रशृंगोन्नतिरिह सप्तमोऽध्यायः)

(च) ५. अवग्रहचिह्न लुप्त

६. "इति" से "अध्यायः" तक लुप्त है ।

(क) १. कोटिकर्ण for (कोटि) २. आर्योष्टादशभिः for (आर्याष्टादश)

प्राक्चन्द्रलग्नयो[३]रस्तलग्नशशिनो [१]यतोन्तरात्पश्चात् ।
[२]प्रतिदिनमिन्दुच्छाया [४]यतस्तदानयनमभिधास्ये ॥ १ ॥
प्रग्रहण[२]कालिकैरिष्टकालिकै[३]र्वार्कलग्नशशिपातैः ।
कृत्वोदयास्तलग्ने स्वचरप्राणान् [१]शंशाकस्य ॥ २ ॥
यद्यधिकमुदयलग्ना[४]दूनं [२]षड्ग्रहयुतास्तमयलग्नात् ।
लग्नं तदा शशांको दृश्यः [१]सवितुर्दर्शने [३]छाया ॥ ३ ॥
[१]लग्नसममुदयलग्नं [३]षड्ग्रहयु[२]तास्त लग्नं [४]समम् ।
पूर्वापरयोः कृत्वा [५]गतशेषाः स्वोदयै[६]र्घटिका ॥ ४ ॥

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१. (घ) १. यतोंतरात् (ग) र्यतोंतरात् (च) for (यतोन्तरात्)
 २. प्रतिदिनछाया for (प्रतिदिनमिन्दुच्छाया)
 (ग) ३. रभ्र for (रस्त)
 ४. ततस्तानयनमभिधास्ये for (यतस्तदानयनमभिधास्ये)
 (च) १. र्यतोंतरात् for (यतोंतरात्)
 (क) यतोऽंतरात् for (यतोन्तरात्)

२. (घ) १. शशांकस्य for (शंशाकस्य)
 (ग) २. काकालिकै for (कालिकै)
 (च) ३. वर्क्कि for (वार्कि)
 (क) १. शशांकस्यात् for (शंशाकस्य)

३. (घ) २. षड्गृह् (ग) for (षड्ग्रह)
 १. सविदर्शने (ग) सतिदर्शने for (सवितुर्दर्शने)
 (ग) ३. छायाः for (छाया)
 (च) ४. दुनं for (दूनं) २. षड्गृह for (षड्ग्रह)
 १. सवितुदर्शने for (सवितुर्दर्शने)
 (क) १. सति for (सवितु)

४. (घ) ३. षड्गृहयुता (ग) (च) for (षड्ग्रहयुता)
 ४. लग्नसमं (ग) (च) for (लग्नंसमं)
 (ग) ५. गशेषाः for (गतशेषाः)
 ६. घटिकाः for (घटिका)
 (क) १. लग्न लग्न for (लग्नं) २. युताश्च for (युतास्त)

गतघटिकाः शेषा वा स्वदिनार्द्धं समावंदी[1]दुरद्धार्द्धे ।
गतशेषनाडिकाभिर्नताभिर[2]थवार्कवच्छं[3]कुः ॥ ५ ॥
शंकुधनुषोऽधिकस्य स्फुटप्रमाणार्द्धं लिप्तिकाभिर्वा[1] ।
रविशशिमध्यगतिक[2]ला तिथ्यंश[3]ज्योनिताछेदः ॥ ६ ॥
द्वादशभिर्गु[7]णिताया दृज्या[1] लब्धमंगुलाद्यं[2] यत् ।
तत्प्रग्र[3]हे छाया[5] स्फुटा न्यादा[4]वान्य[6]थाऽऽसन्ना[8] ॥ ७ ॥

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५. (घ) १. यदींदुमह्लोर्द्धे (ग) यदींदुरह्लोर्द्धे for (वंदीदुरद्धार्द्धे)
२. नवाभि for (नंताभि)
३. रथवार्कवच्छंकुः (ग) for (रथवार्कवछंकुः)

(च) १. यदींदुरह्लोर्द्धे for (वंदीदुरद्धार्द्धे)
२. रथवार्क्क for (रथवार्क)

(क) १. समायदादुराह्लोऽर्द्धे for (समावंदीदुरद्धार्द्धे) २. रस्त्र for (रथ)
३. वत् शंकुः for (वछंकुः)

६. (घ) १. ज्या (ग) र्ज्या for (र्वा)
३. शद्योनिपाछेदः (ग) श ज्योनिवच्छिदः for (शज्योनिताछेदः)

(क) १. र्या for (र्वा) २. तला for (कला) ३. सज्योतिताछेदः for (शज्योनिता-छेदः)

७. (घ) १. १२. दृग्ज्याया (ग) दृक्ज्यांया for (दृज्या)
३. तत्प्रग्रहणे (ग) सा प्रग्रहणे for (तत्प्रग्रहे)
५. छा for (छाया)
४. स्फुटान्य (च) स्फुटान्य for (स्फुटान्या)
६. यथासन्ना (ग) कन्ययासन्ना for (यथाऽऽसन्ना)

(च) ७+१२+ १. दृग्ज्याया for (दृज्या)
३. तत्प्रग्रहणे for (तत्प्रग्रहे) ८. अवग्रहचिह्न लुप्त

(क) १. दृग्ज्याया for (दृज्या) २. मंगुलाप्तं for (मंगुलाद्यं)
प्रग्रहणे for (प्रग्रहे) ४. न्यदा (ग) for (न्यादा)

ज्येष्टापक्रमभागैर्मध्यछायार्कवच्छशांकस्य । [1] [5] [2]
शशिवमादातामृक्षाणां तु स्वकांत ध्रुवकात् ॥ ८ ॥ [3] [4]
इह नोद्दिष्टं यत्तद्रविवद्गतशेषनाडिकाद्येषु । [4] [1]
आर्याभिर्नवाभिरयं चन्द्रछायाऽष्टमोऽध्यायः ॥ ९ ॥ [5] [2] [3]

इति श्री ब्रह्मगुप्ते अष्टमोऽध्यायः ॥

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८. (घ) १. स्वेष्टा (ग) for (ज्येष्टा)

२. वछशांकस्य for (वच्छशांकस्य)

३. शशिवद्भौमादीनामृक्षाणां (ग) शशिवद्भौमादीनां नक्षत्राणां च for (शशि-वमादातामृक्षाणां)

(ग) ४. स्वकाध्रुवकात् for (स्वकांतध्रुवकात्)

(च) ५. छायार्क्कं for (छायार्क) ४. स्वकात् for (स्वकांत)

(क) १. स्वेष्टा for (ज्येष्टा) ३. शशिवत्भौमादीनां नक्षत्राणां स्वकान् ध्रुवकान् for (शशिवमादाता मृक्षाणां तु स्वकांतध्रुवकात्)

९. (घ) २. नवभि for (र्नवाभि)

३. चन्द्रछायां ष्टमोध्यायः for (चन्द्रछायाऽष्टमोऽध्यायः)

(ग) ४. हनोद्दिष्टं for (इहनोद्दिष्टं)

१. यत्तद्रविवत्तच्छेष for (यत्तद्रविवद्गतशेष)

५. आर्यानवभिरयं for (आर्याभिर्नवाभिरयं)

समाप्तिसूचक छः ॥ छः ॥ छः रेखांकित के स्थान में

(च) २. र्नवभिरयं for (र्नवाभिरयं)

३. अवग्रह चिन्हलुप्त

६. छाः श्री for ("इति······अध्यायः")

(क) १. यद्रविवत् for (यत्तद्रविवद्गत) २. नवभिरियं for (र्नवाभिरयं)

३. चन्द्रच्छाया for (चन्द्रछाया)

शून्येशा[७] यमतिथयः[६] षड्गाः षट्भिन्दवः[१] स्वगुण[८] चन्द्राः ।
क्रान्तिर्[२]विक्षेपकालाः[३] कुजबुधगुरुशुक्र[४]रविजानां[५] ॥ १ ॥
११० । १५२ । ७६ । १३६ । १३०
व्यासार्द्धं संयुक्तं त्रिगुणान्त्य फलज्य[६]यान्त्यकर्णोनि[१] ।
त्रिधन[५]गुणं २७[७] स्वदशांशै[२] गुणयांत्य[३] फलज्ययाभक्तं[४] ॥ २ ॥
स्फुटमानकलाभूमिजबुधसुरगुरुशुक्र[१]सूर्यपुत्राणां ।
नाधःस्वयोर्द्र[२]सितयोरासन्नत्वाद्रवेरसितम्[३] ॥ ३ ॥

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१. (घ) ६. मतिथियः (ग) यमातथियः १५२ for (यमतिथयः)
१. षट्त्रींदवः (ग) for (षट्भिन्दवः)
(ग) ७. शून्येंशा ११० for (शून्येशा)
८. १३६ खगुणचन्द्राः for (स्वगुणचन्द्राः)
२. ३. क्रान्तिविक्षेपकला for (क्रान्तिर्विक्षेपकालाः)
(च) ६. तिथियः for (तिथयः) १. षट्त्रींदवः for (षड्भिन्दवः)
(क) १. षट्त्रींदवः for (षट्भिन्दवः) २. क्रान्ते for (क्रान्ति) ३. कला for (कालाः)
४. शुक्रः for (शुक्र) ५. योनाम् for (जानां)

२. (घ) ५. त्रिद्यन (ग) त्रिघनगुणं for (त्रिधनगुणं)
२. स्वद्दशांशै for (स्वदशांशै)
३. गुंणयांत्य for (गुणायांत्य)
(ग) ६. स्वयांत्यकर्णोनम् for (ज्ययान्त्यकर्णोनं)
७. त्यद्दगं दौर्गुण्यांत्यफलभक्तम् ॥ २ ॥ for (स्वदशांशैगुणयान्त्यफलज्याभक्तम् ॥२॥)
(च) ५. त्रिद्यन for (त्रिधन) ७. स्वद्दशंशै for (स्वदशांशै)
३. गुंणयांत्य for (गुणयांत्य)
(क) १. कर्णात् for (कर्णोन) २. द्दगंशैः for (दशांशै) ३. गुणितांत्य for (गुणयांत्य)
४. भक्ता for (भक्तं)

३. (घ) २. स्वयो (ग) नाधस्थयोर्ज्ञ for (नाधः स्वयोर्द्र)
(च) २. स्थयोर्द्र for (स्वयोर्द्र)
(क) १. गुरुदैत्येज्य for (सुरगुरुशुक्र) २. स्थयोर्ज्ञ for (स्वयोर्द्र) ३. रशितम् for (रसितम्)

भुक्त्यंतरेण[1] भुक्तं ग्रहान्तरं[2] फलदिनै[6]रधिकं भुक्तौ जीवरविजानां ।
प्रागूनगतौ[3] पश्चाद्धृ[4]तिरधिके वक्रिणोर्व्यस्ता[5] ॥ ४ ॥
एको वक्रि[3]भुक्त्योर्युत्योनः[1] प्रागथादधिकः[2] ।
पश्चात्[4] ग्रहयोरन्तर लिप्तास्तथैवभक्ताः[5] स्वभुक्तिः[6] गुणाः ॥ ५ ॥
स्वफलमृणं प्राक् पश्चाद्युतौ धनं वक्रिणी[3] ग्रहे[1] व्यस्तम्[4] ।
समलिप्तौ बुधसितशीघ्रचन्द्रपाते[2] च स्वफलम् ॥ ६ ॥

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४. (घ) ६. दिवैरधिकभुक्तौ (ग) दिनैरधिकभुक्तौ for (दिनैरधिकं भुक्तौ)
४. पश्चाद्युति (ग) पश्चाधृति for (पश्चाद्धृति)
५. व्यस्ता भुक्तिगुणाः (ग) व्यस्ताः for (व्यस्ता)
(ग) १, भक्तं for (भुक्तं)
इस श्लोक की प्रथम पंक्ति का अन्तिम शब्द "जीवरविजानां" इस प्रति में उपलब्ध नहीं ।
(च) ६. रधिक for (रधिकं) ४ पश्चाद्युति for (पश्चाद्धृति)
५. व्यस्ता for (व्यस्ता)
(क) १. भक्तं for (भुक्तं) २. ग्रहंतरं for (ग्रहान्तरं) ३. गतै for (गतौ) ४. पश्चात्द्युति for (पश्चाद्धृति)
५. व्यस्तम् for (व्यस्ता)

५. (घ) ३. वक्री (ग) (च) for (वक्रि)
४. पश्चाञ्च्यात् for (पश्चात्)
(ग) १. युत्योनः for (र्युत्योनः)
२. प्रागवाधिकः पश्चात् for (प्रागथादधिकः । पश्चात्)
५. भक्ता for (भक्ताः)
६. भुक्ति (च) for (भुक्तिः) इस श्लोक की प्रथमपंक्ति का अंतिम पद 'पश्चात्' है। अतः दूसरी पंक्ति 'ग्रहयो' से आरम्भ होती है ।
(च) २. प्रागथाऽधिकः for (प्रागथादधिकः)
(क) १. युत्त्यंन for (र्युत्योनः) २. प्रागथाधिकः for (प्रागथादधिकः)

६. (घ) ३. वक्रिणि (ग) for (वक्रिणी)
२. पातेषु च (ग) for (पातेच)
४. व्यस्तः for (व्यस्तम्)
(क) १. ग्रहो for (ग्रहे) २. पातेषु च फलम् for (पाते च स्वफलम्)

बुधसित[1]पाते व्यस्तं [2]मन्दफलमुपान्त्यशीघ्रफलम् ।
शेषाणां स्फुटपातात् [4]विक्षेपो [3]मध्यमात् [5]योगात् ॥ ७ ॥
मदंफलस्फुट शशिनो [5]विक्षेपो भौम[1]गुरुशशिनां च ।
मदं[2]फलव्यस्तस्फुट[4]शीघ्रात् बु[3]धशीघ्रयोरथवा ॥ ८ ॥
सम[3]लिप्ता स्फुटमध्यात् स्वपाता[5]युक्तात् ज्ञः [4]शुक्रयोः शीघ्रात् ।
[1]जीवविक्षेपगुणा [2]हृतात्कर्णेन [6]विक्षेपः ॥ ९ ॥

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७. (घ) ४. विक्षेपोन्मध्यमात् (च) for (विक्षेपोमध्यमात्)
५. पातात् (ग) for (योगात्)
(च) ४. विक्षेपोन् for (विक्षेपो)
(क) १. सितप्ततै र्व्यस्तम् for (सितपातेव्यस्तं) २. सद for (मन्द) ३. मध्यमात्यात् for (मध्यमात्)

८. (घ) १. शनीनां (च) for (गुरुशशिनां च) (ग) जीवर विजानां for (गुरुशशिनां च)
४. शीघ्राद्बुध (ग) for (शीघ्रात्बुंध)
३. शुक्रयोरथवा (ग) for (शीघ्रयोरथवा)
(ग) ५. शुक्रयोरथवा (ग) for (शीघ्रयोरथवा)
(च) १. शनीनां for (शशिनाँ)
२. शीघ्राद्बुधशुक्रयो for (शीघ्रात्बुंधशीघ्रयो)
'क' १. जीवरविजानां for (गुरुशशिनां च) २. फला for (फल) ३. शुक्रयो for (शीघ्रयो)

९. (घ) ३. समलिप्त (ग) (च) for (समलिप्ता)
४. ज्ञशुक्रयोः (ग) (च) for (ज्ञः शुक्रयोः)
१. जीवा विक्षेप (ग) (च) for (जीवविक्षेप)
२. गुणाहृतात्क (ग) गुणाहृतीत्य for (गुणाहृतात्)
(ग) ५. युक्ता for (युक्तात्)
६. विक्षेपाः for (विक्षेपः)
(चं) २. हृतांत्य for (हृतात्)
(क) २. हृतान्य for (हृतात्)

अन्तरयोगो तुल्यान्यदिशोर्विक्षेपयोर्ग्रहांतरकं ।
आर्यभटादिष्ट्रेवं समलिप्तिकयोर्युतिर्ग्रहयोः ॥ १० ॥
चित्रास्वातिवदुदयेऽन्यथान्यथास्ते तथायुतौ ग्रहयोः ।
न भवति दृग्गणितैक्यं यथा तदैक्यं तदुक्तिरतः ॥ ११ ॥
ग्रहयोः स्वोदयलग्ने समलिप्तिकयोस्तदस्तलग्ने च ।
उदये स्वोदयलग्ने स्वषड्गृह स्वास्तलग्नसमे ॥ १२ ॥
कृत्वेवं दिनघटिकाः ग्रहयोः स्वोदयविलग्नयोरूनं ।
अनस्यास्तविलग्नादेष्यताधिकं युतिरविता ॥ १३ ॥

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१०. (घ) २. आर्यभटादिष्वेवं (च) for (आर्यभटादिष्ट्रेवं)
(ग) १. अंतरयोगौ for (अन्तरयोगो)
(च) १. योगौ for (योगो)
(क) १. योगौ for (योगो) २. ष्वेवं for (ष्ट्रेवं)

११. (ग) ३. तदुक्तितरः for (तदुक्तिरतः)
(क) १. दयो for (दये) २. युतिः for (युतौ)

१२. (घ) ४. उदयैः (ग) for (उदये)
(ग) ५. सषड्गृहे for (स्वषड्गृह)
६. स्वास्तमयलग्ने for (स्वास्तलग्नसमे)
(च) ७. ग्रहयो for (ग्रहयोः) ४ उदयैः for (उदयै)
(क) १. +स्फुट ग्रह युति संसाधानाय सम+ २. समा for (सम)
३. लग्नं for (लग्ने) ४. उदयैः for (उदये) ५. स for (स्व)
६. समो for (समे)

१३. (घ) १. ऊनस्वास्त (ग) ऊनं स्वास्त for (अनस्यास्त)
२. देष्यत्यधिकं (ग) दिष्यत्यधिकं for (देष्यतधिकं)
३. युतिरवीता (ग) युतिरतीता for (युतिरविता)
(ग) ४. कृत्वैवं for (कृत्वेवं)
५. लिलग्नयोरूनम् for (विलग्नयोरूनं)
(च) ऊनस्वास्त for (अनस्यास्त)
३. रवीता for (रविता)
(क) १. ऊनस्वास्त for (अनस्यास्त) २. त्यधिक for (तधिकं)
३. रतीता for (रविता)

ऋणमूनं धनमधिकं स्वोदयलग्नात् समस्तलग्नं चेत्भक्ताः ।
भक्ता स्तन्दरकलाः पृथक् पृथक् स्वदिननाडीभिः ॥ १४ ॥
ऋणयोर्वा धनयोर्वान्तरेण मुत्याधनर्णयोर्भक्ताः ।
अन्तरलिप्ताः स्वोदयविलग्नयोर्लब्धघटिकाभिः ॥ १५ ॥
उदयास्तविलग्नान्तरकलागुणाः स्वदिननाडिका भक्ताः ।
लब्धकलादिकमूनं स्वास्त विलग्नादुदयलग्नम् ॥ १६ ॥
यद्यधिकमूनमेवं समलिप्तौ स्वोदयाद्युतौ गृहयोः ।
रात्रिविलग्नादूनावधिकौ षड्ग्रहाद्दृश्यौ ॥ १७ ॥

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१४. (घ) १. स्वमस्त for (समस्त)
२. तदंतरकला: for (तन्दरकला:)
(ग) ३. 'स्व' यह पद यहाँ अंकित नहीं ।
(च) ४. 'भक्ता:' द्वितीय पंक्ति का "भक्तास्" रूप में आरंभिक शब्द है ।
२. मक्तास्तदन्तर कला: for (भक्तास्तन्दरकला:)
'क' २. स्वमस्त for (समस्त)
(ग) २. तदंतर काला: for (तन्दरकला:)

१५. (घ) ३. वोधनयो for (र्वाधनयो)
२. युत्या (ग) युत्तचा for (मुत्या)
(ग) ४. अन्तरलिप्ता for (अन्तरलिप्ता:)
५. स्वाद for (स्वोदय)
(च) ३. र्वोधनयो for (र्वाधनयो)
१. र्वातरेण for (र्वान्तरेण)
२. युत्या for (मुत्या)
(क) १. र्वाऽन्तरेण for (र्वान्तरेण) २. युत्तचा for (मुत्या)

१६. (घ) २. नाडिकभक्ता: for (नाडिका भक्ता:)
१. लब्धकलाधिकमूनं (च) for (लब्धकलादिकमूनं)
(क) २. कलाधिकमूनं (कलादिकमूनं)

१७. (घ) १. षड्ग्रहयुताद् (ग) षड्ग्रहायुता for (षड्ग्रहा)
(च) १. षड्ग्रहयुता for (षड्ग्रहा)
(क) १. षड्ग्रहयुता for (षड्ग्रहा)

एवं मानैक्यार्द्धादधिके[1] मध्यांतरे युतिर्ग्[4]हयोः ।
स्थित्यर्द्ध[2]विमर्द[5]दले हीनेतरा[3] गृहेंदुयुतौ ॥ १८ ॥
लम्बनमर्क[5]ग्रहणवद[1]सकृत्[2]स्वावनतिलिप्तिका[4]स्पष्टौ ।
तात्कालिकविक्षेपौ तदन्तरैक्यं[3] समान्यदिशोः ॥ १९ ॥
विक्षेपो मध्यान्तरमुर्ध्व[1]स्वच्छादको ग्रहोऽधस्थः[2] ।
मानैक्यार्द्धादधिके नातिस्पष्टास्फुटोक्तिरतः ॥ २० ॥

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१८. (घ) ३. ताराग्रहेंदुयुतौ (ग) for (तराग्रहेन्दुयुतौ)

(ग) ४. युतिग्रहयोः for (युतिर्ग्रहयोः)

(च) ५. विमर्द्द for (विमर्द)

(क) १. दधि for (दधिके)

२. स्थित्यर्घ for (स्थित्यर्द्ध)

३. तारा for (तरा)

१९. (घ) ३. तदन्तरेक्यम् for (तदन्तरैक्यम्)

(ग) ४. लिप्ता for (लिप्तिका)

(च) ५. मर्क्क for (मर्क)

(क) १. वत् for (वद)

२. दश कृत for (दसकृत्)

३. तदन्तारैक्यम् for (तदन्तरैक्यम्)

२०. (घ) १. मूर्ध स्वच्छादको ग्रहोधस्थः (ग) मूर्धस्य छादको ग्रहोधस्थः for (मुर्ध्वस्वछादको ग्रहोऽधस्थः)

(च) १. मूर्द्ध for (मुर्ध्व)

२. धस्थ for (ऽधस्थः)

(क) १. मूर्धस्य for (मुर्ध्वस्य)

२. ऽधः स्थः for (ऽधस्थः)

ऊनदिनोदितगुणिता[४]दधिका[३] दिनादूनदिनाहृतालब्धम्[१] ।
अधिकं प्राग्युतिरूनं यद्यधिक दिनोदिनात्पश्चात्[२] ॥२१॥
अन्तरमाद्यो[१] भूयो यदिष्टघटिका[२] फलोनयुतयोश्च[३] ।
प्राक्पश्चाद्वान्तरयो[३]स्तदन्तरेणोद्धृता[४] तदाद्यात्[५] ॥ २२ ॥
युतान्यथेष्ट[१] घटिका गुणितात्फलनाडिकाभिराद्यवशात्[२] ।
प्राक् समलिप्तिकलात्[३]पश्चाद्वा ग्रहयुतिर्भवति ॥ २३ ॥
स्वदिनघटिका विभक्तस्तदुदित[३]परदिवसनाडिकाद्यात्[१] ।
तुल्यः परोदिताभि[२]र्घटिकाभिर्यदियुतिर्ग्रहयोः ॥ २४ ॥

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२१. (घ) ३. अधिक दिनादूनदिनहृताल्लब्धम् (ग) for (अधिकादिनदूनदिनाहृतालब्धम्)
(ग) ४. गणिताद् for (गुणिताद्)
२. दिनोतात्पश्चात् for (दिनोदिनात्पश्चात्)
(च) ३. दधिकदिना for (दधिकादिना)
१. दूनदिनहृताल्लब्धं for (दूनदिनाहृतालब्धं)
(क) १. हृताल्लब्धम् for (हृतालब्धम्) २. सदिनोदिनात्पूर्वे for (दिनोदिनात्पश्चात्)

२२. (घ) १. अन्तमाद्यं for (अन्तरमाद्यो)
(ग) २. न्यदिष्टघटिका for (यदिष्टघटिका)
४. तदन्तरेणोद्धृता for (तदन्तरेणोद्धृता)
५. दाद्यात् for (तदाद्यात्)
(क) १. नाद्यं for (माद्यो) २. ऽन्यदि घटिका for (यदिष्टघटिका)
३. पश्चात् ॥ द्वयन्तरयोः for (पश्चाद्वान्तरयोस्) ४. तदन्तारे for (तदन्तरे)
५. दाधान for (तदाद्यात्)

२३. (घ) १. युत्पान्यथेष्ट (ग) युक्तान्यथेष्ट for (युतान्यथेष्ट)
३. लिप्तिक कालात् (ग) for लिप्तिकलात्)
(च) १. युत्यान्यथेष्ट for (युतान्यथेष्ट)
१. युत्कान्यथेष्ट for (युतान्यथेष्ट) २. ऽराद्यवशात् for (राद्यवशात्)
(क) ३. लिप्तिक कालात् for (लिप्तिकलात्)

२४. (ग) ३. विभक्तात्तदुदित for (विभक्तस्तदुदित)
१. घातः for (घात्)
(क) १. घातः for (घात्) २. परोदिततामि for (परोदिताभि)

विक्षेपमानसमकलदिनघटिकाः स्वोदयास्तलग्नाद्यैः ।
(पंचविंशति) षड्विंशति आर्याणां नवमो ग्रहमेलकोऽध्यायः ॥ २५ ॥
इति ब्रह्मगुप्ते नवमोऽध्यायः ॥

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२५. (घ) २. षड्विंशत्यार्याणां (च) for (पंचविंशति आर्याणां)

(ग) ३. घटिका for (घटिकाः)

दूसरी पंक्ति निम्नांकित है—

'नवमोध्यायोग्रहयुतिरार्याणां पंचविंशत्याः' for (पंचविंशति आर्याणां नवमो-ग्रहमेलकोऽध्यायः)

(च) ४. श्रीः for ("इति...नवमोऽध्यायः")

(क) १. सकल for (समकल)

२. पंचविंशत्यार्यश्च for (पंचविंशति आर्याणां)

अष्टनखैर्मेषगविरदलिप्तोनै गुणैः स्वरैः मिथुने ।
कर्कटके गुणषोडशं धृतिभिः सिंहेन व त्रिधनैः ।। १ ।।
कन्यायां पंचनखैस्तुलिनि अधिधृतिभिरलिनी सेषुकाले ।
द्विचतुर्दशाति धृतिभि धनुषि शंशाक मनुतत्वैः ।। २ ।।

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१. (घ) ५. मोखग (ग) मोषग for (मेंषग)
१. लिप्तोनैर्गण (ग) लिप्तोनैर्गुण for (लिप्तोनैगुणैः)
२. स्वस्वरैर्मिथुने (ग) for (स्वरैं मिथुने)
६. धृतिर्भि (च) for (धृतिभिः)
७. च (च) for (व)

(ग) ३. कक्कंटके गुणषोडश for (कर्कटके गुणषोडशं)
४. त्रिघनैः for (त्रिधनैः)

(च) ५. मेंखे for (मेंष)
१. र्गुणस्वरैर्मिथुने for (गुणैः स्वरैंमिथुने)
८. षोडश for (षोडशं)
४. त्रिद्यनैः for (त्रिधनैः)

(क) १. र्गुण for (गुणैः)
३. कर्कटे for (कर्कटके)
४. त्रिधनैः for (त्रिधनैः)

२. (घ) १. त्र्यतिधृतिभिरलिनि सषुकालेः (ग) त्र्यतिधृतिभिरलिनिसेषुकलैः for (अधिधृतिभिरलिनी । सेषुकाले)
४. धृतिभिर्धनुषि (ग) (च) for (धृतिभिधनुषि)
३. मनुखतत्त्वै (ग) मनुनखतत्त्वैः for (मनुतत्त्वैः)

(ग) २. द्विचतुर्दशानि for (द्विचतुर्दशाति)

(च) १. अतिधृ तिभि रलिनि (अधिधृतिभिरलिनी)
५. क्रमसंख्या लुप्त

(य) १. त्र्यतिधृतिभि रलितेषुकलैः for (अधिधृतिभिरलिनी सेषुकालै)
२. दशा विधृतिः for (दृशातिधृतिभिः)
३. मनुनखै तत्वैः for (मनुतत्त्वैः)

मकरेष्टनखैः कुम्भे नखषड्विंशै ऋर्क्षणे मुनित्रिंशैः ।
पृथगश्विन्यादीनां ध्रुवकाशैर्योगताराश्वः ॥ ३ ॥
ध्रुवकादूनः पश्चादधिकः प्राग्वत् कृतेऽन्यथायोगः ।
अन्यत् ग्रहमेलकवत् ध्रुवक्रान्तेर्भविक्षेपाः ॥ ४ ॥
सौम्यादशार्कविषया याम्या शरदशभवारसासौम्याः ।
खसप्त दक्षिणाः खं सौम्याः सूर्य त्रयोदशकाः ॥ ५ ॥

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३. (घ) ४. नखड्विंशै for (नखषड्विंशै)
१. झँषे (ग) झँषे for (ऋर्क्षणे)
५. मुनिविंशैः for (मुनित्रिंशैः)
२. ध्रुवकांशै (ग) (च) for (ध्रुवकाशै)
(ग) ३. स्वैः for (श्वैः)
(च) १. झँषे (ऋर्क्षषे) for (ऋर्क्षणे)
५. मुनित्रिंशैः ॥३०७॥ for (मुनित्रिंशैः)
३. योगताराश्वैः for (र्योगताराश्वैः)
(क) १. झषे for (ऋर्क्षणे) २. कांशै for (काशै) ३. वेष्ट for (श्वैः)

४. (घ) २. प्राग्वत्कृतेन्यथायोगः (ग) प्राग्वत्कृतेऽथायोगः for (प्राग्वत्कृतेऽन्यथायोगः)
३. ध्रुववक्रांन्तेर्भ for (ध्रुवक्रान्तेर्भ)
(ग) ४. दूने for (दूनः)
५. दधिके for (दधिकः)
१. अन्यद्ग्रहमेलकवद्ध्रुववकक्रान्तेर्भविक्षेपः for (अन्यत् ग्रहमेलकवत् ध्रुवक्रान्तेर्भविक्षेपाः)
(च) २. अवग्रहचिह्नलुप्त १. अन्यद्ग्रह for (अन्यत्ग्रह)
३. ध्रुववक्रांन्ते for (ध्रुवक्रान्ते) ६. विसर्गलुप्त

५. (घ) ४. षं (ग) खं for (ख)
(ग) १. याम्याः for (याम्या)
२. ३. शरदिग्भवारसाः for (शरदशभवारसा)
५. सौम्यां for (सौम्याः)
(च) ६. दशार्क्कँ for (दशार्क) ४. षंसप्त for (खसप्त)
(क) १. याम्याः for (याम्या) २. सर for (शर) ३. दिग् for (दश)
४. खं for (ख)

दक्षिणतो[१]भयमला[३]: सप्त त्रिंशदुदगंशका याम्याः ।
[६]अध्यर्धत्रिचतुष्कार्द्धं नवमसप्त[२]त्रिंशविषय[५]शरा[४]: ॥ ६ ॥
[१]सौम्यादब्[२]धिका यष्टि [७]त्रिंशत् षट्[५]त्रिंशदि[३]तरतो लिप्ताः ।
अष्टादशोत्तरजिनाः षड्विंश[६]त्यंतरा[४]ण्यंशाः ॥ ७ ॥
प्राजेशयो[१]गन्तरा विक्षेपांशै[३] कलात्रिघनहीनैः[५] ।
आग्नेयस्य[४] कला[२]मेकोन त्रिंशताहीनैः[६] ॥ ८ ॥

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६. (घ) ३. अमला for (यमला:)
४. शरा (च) for (शरा:)
(ग) १. भव for (भ)
२. सत्र्यंश for (सप्तत्रिंश)
५. विखय for (विषय)
(च) ३: विसर्गलुप्त ६. अध्यर्द्ध for (अध्यर्ध)
(क) १. भव for (भ) २. शशंश (शत्र्यंश) for (सप्तत्रिंश)
७. (घ) १. सौम्याद्व्यधिका (ग) (च) for (सौम्यादब्धिका)
३. षष्टि (ग) for (यष्टि)
५. षड्विंश for (षट्त्रिंश)
६. षड्वच्‌ंश त्यंतराण्यंशा: for (षड्विंशत्यंतराण्यशा:)
(ग) ७. स्त्रिशत् for (त्रिंशत्)
(च) २. षष्टि for (यष्टि) ७. त्रिंश for (त्रिंशत्)
५. षड्त्रिंश for (षट्त्रिंश)
६. षड्वच्‌ंशत्यंतराण्यंशा: for (षड्विंशत्यंतराण्यंशा:)
(क) १. सौम्यद्व्यधिका for (सौम्यदब्धिका) २. षष्टि for (यष्टि) ३. दिव for (दित)
४. बराण्यंशा: (ग) for (तराण्यंशा:)
८. (घ) १. योगतरा (ग) योगतारा for (योगन्तरा)
३. विक्षेपांशै: (ग) for (विक्षेपांशै)
(ग) ४. आग्रेयस्य for (आग्नेयस्य)
(च) १. योगतारा for (योगन्तरा) ३. विक्षेपांशै: for (विक्षेपांशै)
५. +२७+ ६. +३०+
(क) १. योगतारा for (योगन्तरा)
२. कलानामेकोन (ग) for (कलामेकोन)

पंचदशकला हीनैश्चित्रायाः सप्ततिर्विशाखायाः ।
षट् सप्तत्या मैत्रस्यैंद्रस्य त्रिंशता हीनैः ॥ ९ ॥
छादय योगतारां मानार्द्धोनाधिकाद्द विक्षेपात् ।
स्फुट विक्षेपो यस्याधिकोनको भवति समदिक्सु ॥ १० ॥
विक्षेपोंश द्वितीयादधिको वृषभस्य सप्तदशभागे ।
यस्य गृहस्य याम्यो भिनत्ति शंकट स रोहिण्याः ॥ ११ ॥

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९. (घ) ३. विशाषायाः (च) for (विशाखायाः)
४. मैत्रसौन्द्रस्य (ग) मैत्रस्येन्द्रस्य for (मैत्रस्यैंद्रस्य)
(ग) २. सप्तभि for (सप्तति)
(च) ५. +३०+
(क) १. श्चितायाः for (श्चित्रायाः)
२. सप्तभिः for (सप्तति)

१०. (घ) २. भविक्षेपात् (ग) भवति विक्षेपात् for (विक्षेपात्)
३. समदिक्सुः for (समदिक्सु)
(ग) १. छादयति for (छादय)
(च) २. भविक्षेपात् for (विक्षेपात्)
३. समदिक्सुः for (समदिक्सु)
(क) १. छादयसि for (छादय)
२. भविक्षेपात् for (विक्षेपात्)
३. दिक्स्थः (ग) for (दिक्सु)

११. (घ) ३. विक्षेपौंश for (विक्षेपोंश)
४. द्वितयादधिको (ग) (च) for (द्वितीयादधिको)
(ग) १. वृषस्य for (वृषभस्य)
५. रोहिण्या for (रोहिण्याः)
(च) २. शकटं for (शंकट)
(क) १. मृषभस्य for (वृषभस्य)
२. शकटं (ग) for (शंकट)

विक्षेपेंत्ये[1] सौम्ये[4] तृतीयतारां भिनत्ति[5] पित्र्यस्य[7] ।
इन्दुर्भिन्नति[6] पुष्पं[2] पौष्णं वारुणमविक्षिप्तः[3] ॥ १२ ॥
कृत्वापि[6] दृष्टिकर्म[1] श्रीषेणाचार्यभट[2] विष्नुचन्द्रोक्तम्[3] ।
प्रतिदिनमुदयेऽस्ते[8][5] वा न भवन्ति[4] दृग्गणितयोरैक्यम्[7] ॥ १३ ॥

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१२. (घ) १. विक्षोपंत्ये for (विक्षेपेंत्ये)
४. सौम्ये । २७० । (च) for (सौम्ये)
५. भिनति for (भिनत्ति)
६. इंदुर्भिनत्ति (ग) (च) for (इन्दुर्भिन्नति)

(ग) ७. त्र्यस्य for (पित्र्यस्य)

(क) १. विक्षेपोंऽत्ये for (विक्षेपेंत्ये)
२. पुषां for (पुष्पं)
३. करूण for (वारुण)

१३. (घ) ३. विष्णु (ग) (च) for (विष्नु)
५. मुदयेस्तेवा (ग) for (मुदयेऽस्तेवा)
४. भवति (ग) (च) for (भवन्ति)

(ग) ६. कृत्वा (यहां 'अपि' नहीं है) for (कृत्वापि)
२. श्रीषेणार्यभट for (श्रीषेणाचार्यभट)
७. दृग्गणितरैक्यम् for (दृग्गणितयोरैक्यम्)

(च) ८. प्रतितिदिन for (प्रतिदिन) ५. मुदयेस्ते for (मुदयेऽस्ते)

(क) १. कर्म्म for (कर्म)
२. श्रीषेणार्थ for (श्रीषेणाचार्य)
३. विष्णु for (विष्नु)
४. भवति for (भवन्ति)

भमुनिमृगव्याधानां[7] यतस्तद[1]दृष्टिकर्म[5] वक्ष्यामि[3]।
दृग्गणित[2] सम[4]देयं शिष्याय[8] चिरोषितायेदम्[6] ॥ १४ ॥

अ	भ	कृ	रो	मृ.	आ.	पु.	पु.	अ.	म.	पू	उ	ह.	चि	स्वा	वि[7]	अ.[8]	जे[1]	र[3]
००	००	१	१	२	२	३	३	३	४	४	५	५	६	६	७	७	७	८
८	२०	७	१९	३	७	३	१६	१८	९	२७	५	२०	३	१९	२	१४	१९	१
००	००	२८	२८	००	००	००	००	००	००	००	००	००	००	००	००	००	००	००
००	००	००	००	००	००	००	००	००	००	००	०२	००	००	००	००	००	००	००

श[4]	उ.	अ.	अ	ध	श[5]	पू[6]	उ.	रे
८	८	८	९	९	१०	१०	११	१२
१४	२०	२५	८	२०	१०	२६	७	००
००	००	००	००	००	००	००	००	००
००	००	००	००	००	००	००	००	००

१.४ (घ) १. ततो (च) त for (तद)

३. वक्षामि (ग) कक्षामि for (वक्ष्यामि)

४. समं (च) for (सम)

१. ज्ये	३. मू	६. पू
७		
१९	४. पू	
५		
०		

७. वि	८. अ०	५. श.
७	७	१०
२	१४	२६
५	५	०
०	०	

(ग) ५. दृष्टकर्म for (दृष्टिकर्म)

२. दस्पात्र for (दृग्गणित)

६. विरोषितायेदम् for (चिरोषितायेदम्)

(च) ७. ब्याध्यानां for व्याधानां ३. वक्षामि for वक्ष्यामि

८. सिष्याय for (शिष्याय)

(क) १. ततो for (तद) २. न माणित for (दृग्गणित)

(च) ७. वि. ८. अ. १. ज्ये० ३. मू for (र) ४. पू for (श) ५. श०

७. वि.	८. अ.	१. ज्ये०	३. मू for (र)	४. पू for (श)	५. श०
७	७	१	८	८	१०
२	१४	१९	१	१४	२६
५	५	५	०	०	०
०	०	०	०	०	०

(घ) केवलमात्र परिवर्तित रूप—शेष सब ठीक है ।

वि.	ज्ये०	३. मू.	४. श.	५. श.	६. पू
७	७	८	८	१०	,
२	१९	१	१४	२६	,
५	५	०	०	०	,
०	०	०	०	०	,

अतिरिक्त—

विक्षेपाः

अ	भ	कृ	रो	मृ	आ	पु	पु	अ	म	पू	उ	ह	त्रि
१०	१२	५	५	१०	११	६	०	७	०	१२	१३	१३	२
१													
स्वा	वि	अ	ज्ये	मू	पू	उ	उ	श्र	ध	श	पू	उ	रे
२७	१	०	४	५	५	५	१२	३०	३६	०	२४	२६	०
	३०			२०	२०					१८			

(ग) अश्विन्यादिध्रुवकाः

अ	भ	कृ	रो	मृ	आ	पु	पु	अ	म	पू	उ	ह	चि
०	०	१	१	३	२	३	३	३	४	४	५	५	६
८	२०	७	२९	०	७	३	१६	१०	९	२७	५	२०	३
		२८	२८		०	०	०	०	०	०	०	०	०

स्वा	वि	अ	ज्ये[7]	मू[8]	पू[8]	उ[8]	उ[8]	श्र[9]	ध[9]	श	मू	उ[11]	रे[12]
६	७	७	९	१	२४	२०	२५	८	२०	२०	२०	७	३०
१९	२	१४	५	०	०	०	०	०	०	०	०	०	०
०	५	५	९०	०	०	०	०	०	०	०	०	०	०

क्रांतिज्या[1] तत्क्रान्तिविक्षेप[5]क्रान्तिचापानाम्[2] ।
संयोगान्तर[3]जीवा स्वक्रान्ति[4]ज्यैकभिन्नदिशां[6] ॥ १५ ॥
एवं भमुनिध्रुवयो[1] ग्रहतत्क्रान्त्या चन्द्राष्टकं[2] कर्माद्यं ।
कृत्वा गृहे भमुनिवत् तस्मात्स्वक्रान्ति जीवा वा[3] ॥ १६ ॥

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१५. (घ) २. चापभागानाम् (ग) for (चापानाम्)

(ग) ५. विक्षेप for (विक्षेप)

६. दिशोः for (दिशां)

(च) २. चापनां for (चापानां)

६. द्यैकभिन्नदिशां for (ज्यैकभिन्नदिशां)

(क) १. क्रांति ज्यतिक्राति for (क्रान्तिज्यातत्क्रान्ति)

२. चापभोगाना for (चापानाम्)

३. सोयोगांचर for (संयोगान्तर)

४. क्रातज्यैः कविभिर्मदिशाम् for (क्रातिज्यैकभिन्नदिशाम्)

१६. (घ) १. ध्रुवयोर्ग्रह for (ध्रुवयोग्रह)

२. च दृष्टि कर्माद्यं (ग) for (चन्द्राष्टकं कर्माद्यं)

(ग) १. एवं भमुनेर्ध्रुवयोर्ग्रहवत्क्रान्त्या for (एवं भमुनिध्रुवयोग्रहतत्क्रान्त्या)

३. च for (वा)

(च) २. च दृष्टि for (चन्द्राष्टकं)

(क) १. भमुनिध्रुवका प्राक् प्रदर्शिता त्विषा ।
सेषामेवकार्यं ग्रहस्य पुनातत् क्रान्ते प्रथमं वृत्कर्णं
कृत्वा पश्चात् तज्ज्ञाति स्वक मुनिध्रुवकवत् ।
for
एवं भमुनिध्रुवयो ग्रहतत्क्रान्त्या चन्द्राष्टकं कर्माद्यं ।
कृत्वा ग्रहे भमुनिवत् तस्मात्स्वक्रान्ति जीवा वा ॥ १६ ॥

त्रिज्याप्तांशुभिरुदयैर्घाता द्विक्षेप[५] सत्रिभक्रान्त्ये[२] ।
ऋणधन[३]मेकान्यदिशोस्तयोर्ग्रहेन[४] भमुनि ध्रुवके ॥ १७ ॥
तत्स्वक्रान्तिज्याभ्यां चन्द्रादीनां पृथक् चरप्राणान् ।
कृत्वार्क[३]वत्तदंतरसंयोगो[१] तुल्यभिन्नदिशाम्[२] ॥ १८ ॥
तत्प्राणै[१]र्विक्षेपे सौम्ये हीनो[२] ग्रहोऽधिके[३] याम्ये ।
उदयैर्भध्रुवको वागस्त्यध्रुवकोऽथवा लग्नम्[४] ॥ १९ ॥

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१७. (घ) ५. द्विक्षेप for (द्विक्षेप)
२. क्रान्त्यो (ग) क्रान्त्योः for (क्रान्त्ये)
(ग) १. त्रिज्यासासुभिरुदयैर्घाता ३२७० for (त्रिज्याप्तांशुभिरुदयैर्घाता)
३. रुणधन for (ऋणधन)
(च) इस प्रति में यहां 'विक्षेप' शीर्षक से अतिरिक्त निम्न सारणी दी गई है।

विक्षेपाः

अ	भ	कृ	रो	मृ	आ	पु	पु	अ	म	पु	उ	ह
१८ १	१२	५	५	१०	११	५	०	७	०	१२	१३	१३

चि०	स्वा.	वि	अ	ज्ये	मू	पू	उ	उ	श्र	ध	श	पू	उ	रे
२	२७	१ ३०	०	४	५ २०	५ २०	५	१२	३०	३५	० १८	२४	२६	०

(क) १. सुभिरुदयै for (शुभिरुदयै) २. भक्तम् for (क्रान्त्ये)
३. कर्णमनसे काम्य for (ऋणधनमेकान्य)
४. ग्रहेण for (ग्रहेन)

१८. (घ) १. संयोगौ (ग) संयोगस् for (संयोगो)
(च) ३. कृत्वार्क for (कृत्वार्क)
(क) १. संयोगौ for (संयोगो)
२. दिशम् for (दिशाम्)

१९. (घ) ३. ग्रहोधिको याम्ये (ग) (च) for (ग्रहोऽधिके)
४. ध्रुवकोथवा लग्नम् (ग) (च) for (ध्रुवकोऽथवा लग्नम्)
(क) १. तत्क्रांति ऋणो for (तत्प्राणै)
२. हीने for (हीनो)

उदये गृहभमुनीनाम[3]स्तमये षड्गृहाधिकः[2] सौम्ये[1] ।
अधिको याम्ये हीनः षड्राशियुतोस्तमयलग्नम्[4] ॥ २० ॥
उदयविलग्नादधिके षड्राशि[3]युतास्ते[2] लग्नतो[4] हीने ।
रात्रिविलग्ने दश्यादिनेऽपि[1] चन्द्रोन्यथा दृश्यः ॥ २१ ॥
प्रागुदय लग्न मूनं लग्नादधिकं गृहोदयः पश्चात् ।
ऊनमधिकेन तुल्यं कृत्वा घटिकाः स्वराश्युदयैः[1] ॥ २२ ॥
प्रागस्तमयो लग्नाद्नूनं[5] षड्गृह[1]युतोस्तमय[2]लग्नम् ।
अधिकं पश्चात् घटिकाः[4] कृत्वा[6] सममूनमधिकं चेत्[3] ॥ २३ ॥

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२०. (घ) २. षड्गृहाधिकः (ग) (च) for (षड्ग्रहाधिकः)

(ग) ३. मुनीनां for (मुनीना)

४. ऽस्तमयलग्नम् for (स्तमयलग्नम्)

(क) १. दृक्कर्म कार्यम् for (सौम्ये)

२१. (घ) २. त (ग) (च) for (ते)

१. दृश्यो दिनेपि (ग) दृश्यो दिनेऽपि for (दश्यादिनेऽपि)

(घ) ३. षड्राश for (षड्राशि)

(च) ४. लग्नांतो for (लग्नतो) ।

(क) दश्योदिमेपि for (दश्यादिनेऽपि)

२२. (च) १. राश्युदयो for (राश्युदयैः)

२३. (घ) १. षड्गृह (ग) (च) for (षड्ग्रह)

२. युतास्तमय (ग) for (युतोस्तमय)

४. पश्चाद्घटिकाः (ग) for (पश्चात्घटिकाः)

(ग) ३. अधिकेन for (अधिकं चेत्)

(च) ५. दुनं for (द्नूनं)

४. पश्चाध्यघटिकाः for (पश्चात् घटिकाः)

६. कृत्वा for (कृत्वा)

(क) १. षड्गृह for (षड्ग्रह)

२. युतास्तमय for (युतोस्तमय)

३. अधिकेन for (अधिकं चेत्)

तात्कालिकोपकरणैः सकृदागतनाडिकाभिरह्नींदौ ।
रात्रौ वा प्रति घटिकं प्राग्वच्छृंगोन्नतिः धार्या ॥ २४ ॥
मध्यछाया रविवत् स्वक्रान्त्या दर्शनेमनीष्टाच ।
एवं भ मुनीनामन्तर घटिका गुणं भुक्तिः ॥ २५ ॥
षष्ट्या विभजेत् लब्धं प्रागुदयास्तमययोः ग्रहे शोध्यम् ।
पश्चात् क्षेप्यं प्रतिदिनमुदयस्तमयासकृदेवं ॥ २६ ॥

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२४. (घ) १. रह्नींदो (ग) रह्नींदोः for (रह्नींदौ)
४. कार्याः (च) for कार्या
(ग) १. सकृतागत for (सकृदागत)
५. तात्कालिकोपकरणे for (तात्कालिकोपकरणैः)
(क) १. शकृद् for (सकृदागत) २. रह्नीदोः for (रह्नींदौ) ३. रात्रो for (रात्रौ)
३. घटिका for (घटिकं)

२५. (घ) ३. कांत्या for (क्रान्त्या)
१. सतीष्टा (ग) सती च for (मनीष्टा)
५. एवं ग्रह (ग) for (एवंभ)
६. मनीना (ग) मुनीना for (मुनीना)
७. गुणां for (गुणं) (ग) गुणाभक्तम् for (गुणं भुक्तिः)
(च) १. सतीष्टा for (मनीष्टा)
५. एवंग्रहभ for (एवंभ)
(क) १. सतीष्टा for (मनीष्टा) २. ग्रह for (भ) ३. भुक्तिम् for (भुक्तिः)

२६. (घ) ३. विभजेल्लब्धं (ग) for (विभजेत्लब्धं)
४. ग्रंह (ग) ग्रंहे (च) for (ग्रहे)
५. उदयास्त (ग) for (उदयस्त)
६. मयावसकृदेवं (ग) for (मयासकृदेवं)
(च) ३. विभजेलब्धं for (विभजेत्लब्धं)
७. विसर्गलुप्त
१. पश्चाक्षेप्यं for (पश्चात्क्षेप्य)
६. मयावसकृदेवं for (मयासकृदेवं)
(क) १. क्षेप्यत्र for (क्षेप्यं)
२. सकृदवम् for (सकृदेवं)

इष्टात्कालात् भानोरुदयास्ताद्वा ग्रहोदयास्तमयैः ।
तात्कालिकै र्विलग्नग्रहोदयास्तमयलग्नाद्यैः ॥ २७ ॥
प्रागुदयलग्नमुदयैर्लग्नसमं लग्नमुदयलग्नेन ।
पश्चात् तत् घटिकाभिः कृत्वा तात्कालिकैरसकृत् ॥ २८ ॥
उदयं प्रागस्तमयो लग्नेन पश्चानषड्ग्रहास्तमयः ।
लग्नं पश्चाल्लग्नचक्रार्द्धं संयुतास्तमये लग्नेन ॥ २९ ॥
उनोल्पभुक्तिरुदितः प्रागथवो देष्यति ग्रहः सूर्यात् ।
पश्चादधिकोधिकगतिरल्पगती वक्रितौ ज्ञसितौ ॥ ३० ॥

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२७. (घ) २. कालाद्भानो (ग) (च) for (कालात् भानो)
१. मयै (ग) मयौ for (मयैः)
३. र्विलग्न (ग) (च) for (र्विलग्नं)

(ग) ४. इष्टा for (इष्टात्)
५. होदयास्तमय......for (ग्रहोदयास्तमय)

(च) १. मयै for (मयैः)

(क) १. मयौ for (मयैः)

२८. (घ) ३. पश्चात्तद्घटिकाभिः for (पश्चात् तत् घटिकाभिः:)
५. पश्चात्त for (पश्चात् तत्)
(च) ५. पश्चाद्घटिकाभिः for (पश्चात्तत् घटिकाभिः) ६ क्रत्वा for (कृत्वा)
(क) १. मदयै for (मुदयै) २. मदय for (मुदय)

२९. (घ) १. सषड्ग्रहास्तमयलग्नम् (ग) (च) for (पश्चानषड्ग्रहास्तमयः । लग्नम्)
३. पश्चाल्लग्नं (ग) for (पश्चाल्लग्न)
(ग) ४. उदयः for (उदयं)
२, मय for (मये)
(क) १. सषट् ग्रहास्तमय लग्नम् for (पश्चानषड्ग्रहास्तमयः लग्नम्)
२. मय for (मये)

३०. (घ) १. ऊनोल्पभुक्तिरुदितः (ग) (च) for (उनोऽल्पभुक्तिरुदितः)
(क) १. दर्ष्यति for (देष्यति)

प्रागूनाधिकभुक्तिः[१] पश्चादधिकोल्पभुक्तिरस्तमितः[२] ।
यास्यत्यथवास्तमयं यतस्ततो दृश्यघटिकोक्तिः ॥ ३१ ॥
घटिकाद्वयेन चन्द्रो दृश्योर्कात्[५] सितगुरुज्ञ[१] शनिभौमाः ।
अध्यर्द्धया घटिकाया[२] त्रिभागघटिको[३] ज्ञ (त्त) राधिकाया ॥ ३२ ॥
गृहसूर्यान्तरघटिका[४] स्वभुक्ति लिप्तानि[१] स्वनयुतयोश्च[५][८] ।
प्राग्वदनंतर[२] हृताहीनाधिकनाडिका[३] दिवसाः[६] ॥ ३३ ॥

चं	शु	बृ	बु	श	मं
२	३०	१	२	१	२
००	००	५०	००	३०	५०

[७]

३१. (घ) १. प्रागूनोधिकभुक्तिः for (प्रागूनाधिकभुक्तिः)
(क) २. संमितः for (स्तमितः)
३२. (घ) १. घटिकया (ग) (च) for (घटिकाया)
३. घटिकोत्तराधिकया (ग) (च) for (घटिकोत्तराधिकाया)
(ग) ४. अध्यर्द्ध्य for (अध्यर्द्धया)
(च) ५. दृश्योर्क्कात् for (दृश्योर्कात्)
(क) १. शित for (सित) २. घटिकया for (घटिकाया) ३. शशिकोत्तरा for (घटिकोत्तरा)

[७]

चं.	शु०	बृ०	बु०	श०	मं
३	१	१	२	२	२
	३	५०	१०	३०	५०

३३. (घ) ४. घटिकाः (ग) (च) for (घटिका)
५. स्वनयुतयोश्च (च) for (स्वनयुतयोश्च)
२. प्राग्वत्तदंतर (च) for (प्राग्वदनंतर)
३. हृता (ग) कृता for (हृता)
६. दिवसा (च) for (दिवसाः)
(ग) ८. युततयोश्च for (युतयोश्च)
(च) ३. हृता for (हृता)
(क) १. लिप्ताभिस्वन for (लिप्तानिस्वन)
(ग) २. तदंतर for (दनंतर)
३. हवा for (हृता)

[७]

चं	शु०	बृ०	बु०	श०	मं०
३	१	१	२	२	२
	३	५०	१०	३०	५०

विपरितधनमृणं सौम्यशुक्रयोर्वक्रिणोः स्वभुक्तिकलाः ।
एवमुदयास्तमययो विपरितं वक्रिणः स्वफलम् ॥ ३४ ॥
विक्षेपो दक्षिणतस्तक्रांतेर्भाग सप्तसप्तत्या ।
मिथुनस्य सप्तविंशे भागेनस्त्योन्नतैर्भागैः ॥ ३५ ॥

३४. (घ) ६. विपरीत (ग) for (विपरित)
७. विक्रणोः for (वक्रिणो)
३. एवनुदयास्तमययो (ग) एवमुदयास्तमययो for (एवमुदयास्तमययो)
८. विपरीतं (ग) for (विपरितं)

(ग) १. रुणधनं for (धनमृणं)

(च) ७. ि.क्रिणों for (वक्रिणोः)
८. विपरितं for (विपरितं)

(क) १. ॠणधनं for (धनमृणं)
२. कालः for (कलाः)
२. उदक for (उदया)
४. वक्रिणि (ग) for (वक्रिणः)
५. फलाम् for (फलम्)

३५. (घ) १. विक्षिप्तो (ग) for (विक्षेपो)
२. वक्रांते (ग) तत्क्रान्ते for (तक्रान्ते)
३. नस्त्योन्नतै भागैः (ग) गस्त्योनतैर्भागैः for (नस्त्योन्नतैर्भागैः)

(ग) ४. 'सप्त' यह पद यहां अंकित नहीं ।

(च) १. विक्षेप्रो for (विक्षेपो)
२. तत्क्रांते for (तक्रान्ते)
३. नस्त्योन्नतैभागैः for (नस्त्योन्नतैर्भागैः)

(क) १. विक्षिप्तो for (विक्षेपो)
२. स्व for (स्त)
३. भागेरगेस्त्योर्नतैः for (भागेनस्त्योन्नतै)

नवते[1]स्तनैर्दृश्यो [3]घटिकाद्वितयेन [2]तदुदयविलग्नम्
[6]उदयैरधिकं [7]कृत्वा [4]तदुदयसूर्योस्तमयलग्नम् ॥ ३६ ॥
[5]षड्भयुतमूनमुदयैः [1]षड्राशियुतं [2]तदस्तमयसूर्यः ।
[3]घटिकाद्वितयेनैवं [4]षड्भागयुतेन [6]मृगेहंतु ॥ ३७ ॥
एवं [4]नक्षत्राणां घटिका[5]द्वितयेन [1]सत्रिभागेन ।
[2]उदयार्कोस्तमयार्का [3]व्यस्तोनस्तत्सदादृश्यम् ॥ ३८ ॥

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३६. (घ) १. रूनैर्दृश्यो (ग) रूनैर्दृश्यो for (स्तनैर्दृश्यौ)
३. ६० घटिका for (घटिका)
(ग) ४. तद्रुदय for (तदुदय)
(घ) ५. [2]रूनैर्दृश्यो ६० for (स्तनैर्दृश्यो)
६. रुदयै for (उदयै) ७. क्रत्वा for (कृत्वा)
(क) १. रूनै for (स्तनै) २. विलग्नम) for (तदुदयविलग्नम्)

३७. (घ) २. तदस्तमसूर्यः for (तदस्तमयसूर्यः)
३. घटिद्वितयेनैवं for (घटिद्वितयेनैवं)
४. षड्भागायुतेन (च) for (षड्भागयुतेन)
(ग) ५. भार्द्धयुत for (षड्भयुत)
६. हंतुः for (हंतु)
(च) ७. मृगहंतु for (मृगेहन्तु)
(क) १. रासि for (राशि)

३८. (घ) १. सतृभागेन (च) for (सत्रिभागेन)
३. व्यस्योनस्तत्सदा (च) for (व्यस्तोनस्तत्सदा)
(ग) ४. नक्षत्राणामेवं for (एवं नक्षत्राणां)
५. द्वितेन for (द्वितयेन)
२. उदयार्को मस्तयकार्द्व्यस्योनस्तदादृश्यम् for (उदयार्कोस्तमयार्का व्यस्तोनस्तत्सदादृश्यम्)
(च) २. उदयार्क्कोस्तमयार्क्का for (उदयार्कोस्तमयार्का)
(क) १. त्रिभागेन for (सत्रिभागेन २. उदय (लक्षय) लग्नमधिकं कृत्वा पूर्ववदुदयास्स्तार्या भवंति for (उदयार्कोस्तमयार्काव्यस्तौनस्तदादृश्यम्)

उदयास्तसूर्योरन्तरे[1] रवौ दृश्यते[4]ऽन्यथास्तमितः[2] ।
उनाधिकार[3]विकला रविभुक्त्या भाजिता दिवसाः ॥ ३९ ॥
षड्विंशो[1] मिथुनांशेः[6] शकचत्वारिंशता ४० मृग व्याधः[2] ।
तक्रांते[5]र्दक्षणतो[3] विक्षिप्तागस्त्य[4]वच्छेषम् ॥ ४० ॥
गुणिता व्यासार्द्धेन स्वक्रान्तिज्यावलंबकहताग्रा[1] ।
प्रतिदिनमुदयास्तमया वर्गाग्रे[2] भग्रहमुनीनो[3] ॥ ४१ ॥

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३९. (घ) १. उदयास्तसूर्यायारंतरे (ग) उदयास्तासूर्ययो for (उदयास्तसूर्योरंतरे)
२. स्तमित for (स्तमित) (ग) न्यथास्तमितिः for (ऽन्यथास्तमितः)
३. ऊनाधिकार (ग) for (उनाधिकार)
(ग) ४. दृश्यतेः for (दृश्यते)
(च) १. उदयास्तसूर्यायोरन्तरे for (उदयास्तसूर्योरन्तरे)
२. न्यथास्तमित for (ऽन्यथास्तमित)
(क) ६. सूययोरन्तर for (सूर्योरन्तरे)

४०. (घ) १. षड्विंशे (ग) (ग) for (षड्विंशो)
५. तत्क्रांतेर्दक्षिणतो (ग) तत्क्रांतोर्दक्षिणतो for (तक्रान्तेर्दक्षणतो)
४. विक्षिप्तोगस्त्यवच्छेष (ग) विक्षिप्तोगस्त्यवछेषम् for (विक्षिप्तागस्त्य-वच्छेषम्)
(ग) ६. मिथुनांशेऽशक for (मिथुनांशेः शक)
(च) ५. तत्क्रांते for (तक्रांते)
३. र्दक्षिणतो for (र्दक्षणतो)
(क) १. विंशे for (विंशो) २. व्याधेः for (व्याधः) ३. दक्षिणे for (र्दक्षणतो)
४. विक्षेपोऽगस्त्य for (विक्षिप्तागस्त्य)

४१. (घ) १. ज्यावलंबलकहताग्रा (ग) ज्यावलंबकोद्धृता स्वाग्रा for (ज्यावलंबकहताग्रा)
२. वग्राग्रे (ग) for (वर्गाग्रे)
३. मुनीनाम् (ग) भग्रहमुनीनाम् (च) for (भग्नहमुनीनो)
(च) १. हृताग्रा for (हताग्रा)
(क) १. प्रतिदिनमुदयास्तमयावयात्रे वग्रहमुनीरमां
गुणिता व्यासार्द्धेन स्वक्रान्तिज्या सार्द्धेनानेन
for (गुणिता व्यासार्द्धेन स्वक्रान्तिज्या वलंबकहताग्रा । प्रतिदिनमुदयास्त-मया वर्गाग्रे भग्नहमुनीनो ॥)

अग्राशंकुतलैक्यं[1] तुल्यदिशोरन्तरं तथान्यदिशो[4] ।
प्राच्यपरायाः[5] शंकोः[6] तलं[3] दग्ग्रे गृहो नं[2] च ॥ ४२ ॥
शंकुतल प्राच्यपरांतरं भुजो दक्षिणोत्तरं कर्णः[2] ।
दग्ज्या[1] तद्वर्गांतरमूलं दिग्मध्यतः[3] कोटिः ॥ ४३ ॥
उनाधिकशंकुगुणाः[3] स्वशंकुभक्ताः पृथक् स्वदग्ग्याग्रे[1] ।
कृत्वोनाधिक[6]शंकु[4]दृष्टिं[5] कृत्वोनशंक्वग्रे[2] ॥ ४४ ॥

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४२. (घ) ३. शंकोस्वलं तदग्रे for (शंकोः तलं दग्रे)
२. भं वा (ग) for (नं च)

(ग) ४. तथान्य दिशोः for (तथान्यदिशो)
५. परयोः for (परायाः)

(ब) ६. शंको for (शंकोः)
३. तलं तदग्रे for (तलंदग्रे)

(क) १. तलेक्यं for (तलैक्यं) २. भ वा for (नं च)

४३. (घ) २. दक्षिणोत्तरः (ग) (च) for (दक्षिणोत्तरं)
१. दृग्ज्यातद्वर्गांतर मूलं (ग) (च) for (दग्ज्यावर्गान्तरमूलं)
३. दिग्मध्यत (च) for (दिग्मध्यतः)

(क) ६. दुप उप स्वर्गांतर मूलं for (दग्ज्यातद्वर्गांतरमूलं)

४४. (घ) ३. ऊनाधिक (ग) (च) for (उनाधिक)
१. दृग्याग्रे (ग) सुदृग्ज्याग्रे for (स्वदग्याग्रे)
४. शंक for (शंकु)
२. शंक्वाग्रं (शंक्वग्रे) (ग) शक्वग्रे for (शंक्वग्रे)

(ग) ५. दृश्यं for (दृष्टिं)

(च) १. स्वदृग्याग्रे for (स्वदग्याग्रे)
६. कृत्वो for (कृत्वो)
२. शंक्वग्रे for (शंक्वग्रे)

(क) १. दृस्या for (स्वदग्याग्रे) २. शंकुः for (शंक्वग्रे)

प्रतिघटिकमधिकशंकोग्र्[1] हमध्ये[5] दर्शयेत्[6] भुवा ।
त्रिप्रश्नोत्तया[2] रविवच्छंकु[3] भ्रमणादिक्रमशेषम्[4] ॥ ४५ ॥
शंकु प्राच्यपरांत्तरं[2] विषुवच्छायैक्य मुत्तरे[4] नृतले[3] ।
याम्योतरं[1] गुणहतं[5] स्वक्रान्तिर्लम्ब कर्णाभ्याम् ॥ ४६ ॥
तच्चापांशा[4] सदशैः[1] मंधुवकापक्रमांशकैरूना[2][5] ।
विक्षेपांशे[3] व्यस्ता[6] व्यस्तविशुद्धा व्यसदृश्यांशैः[7] ॥ ४७ ॥

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४५. (घ) ५. मग्रें (ग) ग्रहमग्रे
६. दर्शयेनि (ग) दर्शयेन्मुनि भंवा for (दर्शयेत् भुवा)
३. रविवत्शंकु (च) for (रविवच्छंकु)
४. कमशेषम् (ग) (च) for (क्रमशेषम्)
(ग) २. त्रिप्रस्नोक्तं for (त्रिप्रश्नोत्तया)
(च) २. मग्रें for (मध्ये) ६. दर्शयेनि for (दर्शयेत्)
(क) १ अधिघटिकादिसमधिशंका ग्रहणं मग्रे दर्शयन् मुनिनंद for (प्रतिघटिकमधिकशंकोग्र हमध्ये दर्शयेत् भुवा)
२. तृः for (त्रि) ३. विवन् for (रविव) ४. कमा for (क्रम)

४६. (घ) २. परांतर (ग) (च) for (परांत्तरं)
३. नृतरे for (नृतले)
१. याम्येंतरं (ग) याम्यैरंतर for (याम्योतरं)
(च) ४. मुत्तर for (मुत्तरे)
५. गुणहृतं for (गुणाहतं) १. याम्योत्तरं for (याम्योतरं)
(क) १. याम्येंतरे for (याम्योत्तरं)

४७. (ट) ४. चापांशाः (ग) (च) for (चापांशा)
१. सद्दशैः (ग) (च) for (सदशैः)
५. रूनाः (ग) for (रूना)
३. विक्षेपांशा (ग) विक्षेपांशाद्व्यस्ता for (विक्षेपांशे व्यस्ता)
६. व्यस्तविशुद्धाव्यसदृश्यांशैः (ग) विस्तविशुद्धा for (व्यस्तविशुद्धाव्यसदृश्यांशैः)
(ग) २. भंध्रुवका (च) for (मंधुवका)
७. वसद्रिशांशैः for (व्यसदृश्यांशैः)
(क) १. सद्दशै for (सदशैः) २. ध्रुवकः for (मंधुवकः) ३. पांशा for (पांशे)

सहिता विक्षेपांशस्[4]तत्क्रापांशकवशादुदग्याम्या[1] ।
एवं विक्षेपांशाः[2] तक्रांत्यंशैर्[5]ध्रुवो[3] रविवत् ॥ ४८ ॥
उनैमानैक्याद्धात्[2] ग्रहयोमध्यांतरे[3] युतिर्ग्रहयोः[4] ।
समलिप्तिकयो ग्रहणादधिके[1] स्फुट मानयोगार्द्धात्[5] ॥ ४९ ॥
समलिप्तिकालिकार्कात्[4] कृत्वा लग्नं स्वदेश[3]राश्युदयैः[2] ।
ग्रहयोः समलिप्तिकयोः स्वदिनोदिननाडिका[6][1] प्राग्वत्[5] ॥ ५० ॥
अधिकदिनोदितघटिकाभिरूनदिननाडिका गुणा भक्ताः[3] ।
अधिकदिननाडिकाभिः[1] फलनाड्यो[2] यदि भवन्त्यूनाः[4] ॥ ५१ ॥

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४८. (घ) ४. विक्षेपांशा (ग) for (विक्षेपांश)
१. याम्याः (ग) (च) for (याम्या)
५. तत्क्रांत्यंशै (च) for (तक्रांत्यंशै)
(ग) २. विक्षेपांशैस्तत्क्रान्त्यशा for (विक्षेपांशाः त क्रांत्यंशै)
(क) १. यामा: for (याम्या) २. विक्षेपाश for (विक्षेपांशाः)
३. जातैविक्षेपानयनम् for (ध्रुवोरविवत्)

४९. (घ) २. ऊनेमानैक्यार्द्धा (ग) (च) for (उनैमानैक्यार्द्धात्)
३. ग्रहयोर्म्मध्यांतरे (ग) (च) for (ग्रहयोमध्यांतरे)
४. ग्रहयैः for (ग्रंहयोः)
(ग) १. ग्रंहणवदधिके for (ग्रहणादधिके)
५. योगार्द्धा for (योगार्द्धात्)
(च) ४. ग्रहयौः for (ग्रंहयोः)
(क) १. वदधिके for (दधिके)

५०. (घ) २. राश्युदयै (ग) for (राश्युदयैः)
१. नाडिकाः (ग) स्वदिनोदितनाडिका for (स्वदिनोदिननाडिका
(ग) ३. स्वदेदेश for (स्वदेश)
(च) ४. कालिकार्क्कात् for (कालिकार्कात्)
१. स्वदिनोदिननाडिकाः for (स्वदिनोदिननाडिका)
५. प्रग्वत् for (प्राग्वत्)
(क) ६. स्वदितनाडिका for (स्वदिनोदिननाडिका) ४. कति for (कात्)

५१. (घ) २. नाड्ये for (नाड्यो)
(ग) ३. भक्ता for (भक्ताः) ४. भवत्यूनम् for (भवन्त्यूनाः)
(क) १. गुण for (दिन)

उनदिवसो[2] दिताभ्यो घटिकाभ्यः प्रागथाधिका[3]: पश्चात् ।
योगस्तत्[5] घटिकांतरमाद्यं[1] कृत्वेषु[4] घटिकाभिः ।। ५२ ।।
गुणिता[2] स्वभुक्तलिप्ता[3] षष्टिहृताः[4] प्रागण[1] धनं पश्चात् ।
आद्यवदन्तरमन्यत्प्राक्[6] पश्चाद्धान्तिर[5] द्वितयम् ।। ५३ ।।
आद्य[3]घटिकान्तरं[4] वशात्प्राक् पश्चाद्द्वा युतिः प्रथमकलात्[1] ।
कृत्वा पृथकदिनोदित[5] घटिकास्तत्कालिक[2] ग्रहयोः ।। ५४ ।।

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५२. (घ) २. ऊन (ग) ऊनादिवसो (च) for (उनदिवसो)
(ग) ३. प्रागधिकाः for (प्रागथाधिकाः)
४. कृत्वेष्ट for (कृत्वेषु)
(च) ५. योगस्तद्घटिकांतरमाद्यं for (योगस्तत् घटिकांतरमद्यं)
(क) १. घटिकादिफलं ग्राह्यं for (घटिकांतमाद्यं)
२. यदिभरमाद्यं कृत्वेष्ट for (घटिकांतरमाद्यं कृत्वेषु)
५३. (घ) २. गुणिताः for (गुणिता)
३. लिप्ता (ग) (च) for (लिप्ता)
१. प्राग्रणं (ग) (च) for (प्रागणं)
(ग) ४. षष्टिहृताः (च) for षष्टिहृताः)
५. पश्चाद्वान्तर for (पश्चाद्धांतिर-द्धांतर-)
(क) १. प्राग्रण for (प्रागणं) २. गुणिताः for (गुणिता) ३. लिप्ताः for (लिप्ता) ५. पश्चाद्वांतर for (पश्चाद्धान्तिर-द्धांतर)
६. मन्यत्प्रा for (मन्यत्प्राक्)
५४. (घ) ३. अद्य (च) for (आद्य)
४. घटिकान्तरवशात् (ग) आद्यवटिकांतरवशा for (घटिकांतरं वशात्)
५. पृथगुदितोदित (ग) पृथग्दिनोदित for (पृथकदिनोदित)
(ग) २. तात्कालिकग्रहयोः for (तत्कालिकग्रहयोः), इसकी श्लोक संख्या ५५ है।
(च) ४. घटिकांतरवशात् for (घटिकांतरवशात्)
५. पृथगुदिनोदित for (पृथक्दिनोदित)
(क) १. कालात् for (कलात्) (ग) २. कोलिक for (कालिक) इसकी श्लोक संख्या ५५ है।
(ग) यद्याद्यान्यांतरयोरन्तर हृत मन्यथा तदैक्येन ।
गाद्यन्तरष्टिभिर्घटिका निर्गुणित माप्ताभिः ।। ५४ ।।
इसमें यह अतिरिक्त श्लोक पाया गया है।
(क) १. आद्यंतर for (प्राद्यंतर)

उदितघटिका यदि हृता गुणिताश्चाद्यान्यदिवसघटिकाभिः ।
यद्याद्यानान्तरयोरंतर हृतमन्यथा तदैक्येन ॥ ५५ ॥

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५५. (क) १. हृता for (हृता) २. स्वान्य for (द्यान्य)

३. अन्योदितटिकाभिस्तुल्यो योगोभवेदसकृत् for (यद्याद्यानांतरयोरंतरहृतमन्यथा तदैक्येन) इसकी श्लोक संख्या ५६ है।

(क) यद्याद्यान्यान्तरयोरन्तर हृतमन्यथा तदक्येन ।
आद्यंतरमिष्टाभिर्घटिकाभि गुणितमाप्ताभिः ॥ ५५ ॥

for

उदितघटिका यदि हृता गुणिताश्चाद्यान्यदिवसघटिकाभिः ।
यद्याद्यानाँतरयोरंतर हृतमन्यथा तदैक्येन ॥ ५५ ॥

(घ) १. हृता (ग) (च) for (हृता)

२. गुणिताश्चश्चा (ग) गुणिताश्चस्वान्य for (गुणिताश्चाद्यान्य)

३. यद्याद्यान्यांतर for (यद्याद्यानांतरयोरंतर)

वि०—इस श्लोक में एक और पंक्ति है और उसके पश्चात् क्रमसंख्या ५४ लिखी है। पंक्ति है —

"आद्यंतरमिश्चार्दांतरै द्वितयं । ष्टाभिर्घटिकाभिर्गुणितमास्ताभिः ॥ ५४ ॥
for (यद्याद्यानाँतरयोरन्तरहृतमन्यथा तदैक्येन)

(ग) ५. उदकैत for (उदित)
वि० इसका उत्तरार्ध निम्नांकित है—श्लोक संख्या ५६ है।
'अन्योदितघटिकाभिस्तुल्यायोगो न चेदसकृत' for (यद्याद्यानांतरयोरंतर हृतमन्यथा तदैक्येन)

(च) २. गुणिताश्चश्चान्यदिवसघटिकाभि for (गुणिताश्चाद्यान्यदिवसघटिकाभिः)

३. यद्याद्यान्यांतरं for (यद्याद्यानांतरयोरंतर)

६. हृतमन्यथा for (हृतमन्यथा)

आद्यंतरमिष्टाभिर्घटिकाभिर्गुणितमाप्ताभिः ।
अन्योदित घटिकाभिस्तुल्यो योगो भवेदसकृत् ॥ ५६ ॥
अन्येष्टनाडिकाभिः कृत्वा तुल्या यदा तदा योगः ।
कार्यो अंगोन्नतिवत् गृहमध्यान्तरे योगे ॥ ५७ ॥

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५६. (क) उदितघटिका यदि हृता गुणिताश्च स्वान्यदिवस घटिकाभिः ।
अन्योदित घटिकाभिस्तुल्यो योगो भवेदसकृत् ॥ ५६ ॥
for
आद्यंतरमिष्टाभिर्घटिकाभिर्गुणितमाप्ताभिः ।
अन्योदित घटिकाभिस्तुल्यो योगो भवेदसकृत् ॥ ५६ ॥

(वि) इस श्लोक का पूर्वार्ध —अतिरिक्त ५४ का उत्तरार्ध भी है।

(घ) वि० इस श्लोक की पहली पंक्ति पिछले श्लोक की अंतिम पंक्ति दर्शाई गई है। क्रम संख्या ५४ लिखी है।
१. 'भिश्चाद्यंतरे द्वितयं, ष्टाभिर्घटिकाभिर्गुणितमास्ताभिः ॥ ५४ ॥' इस पंक्ति के पश्चात् ५५ संख्या कहीं नहीं है । हां "अन्योदित ········असकृत" लिखकर ॥ ५६ ॥ संख्या लिखदी है।

(ग) यह श्लोक इस प्रति में नहीं है।
इसकी पहली पंक्ति—ग के ५४ संख्यावाले श्लोक की दूसरी पंक्ति है। तथा ग के ५६ संख्या वाले श्लोक की दूसरी पंक्ति, इसकी दूसरी पंक्ति है। देखो पिछला श्लोक।

(च) २. यहां पर भी क्रमसंख्या ५६ दी हुई है।

५७. (घ) २. शृंगोन्नतिवद्ग्रहमध्यांतरे (ग) शृंगोन्नतिवद्ग्रहयो for (अंगोन्नतिवत् ग्रहमध्यान्तरे)
१. कार्यों for (कार्यो)
३. मंध्यान्तरे for (मध्यांतरे)
इसकी श्लोक संख्या मिलती जुलती है।

(च) ४. क्त्वा for (कृत्वा) शृंगोन्नतिवद्ग्रहमध्यांतरे योगे for (अंगोन्नतिवत् ग्रहमध्यांतरे योगे)

(क) १. कायो for (कार्यो) २. शृङ्गान्नति for (अंगोन्नति)
३. ग्रहयोम् for (ग्रहमध्यांतरे) ४. योगः for (योगे)

बाहु[५] संयोगांतरमन्नाशंक्[१]वग्रयोः समान्य[२]दिशोः ।
करणो[२]दग्ज्येकोटि[३] स्वकर्णभुजकृतिविशेष[४]पदे ॥ ५८ ॥
कोटिभुजकर्ण[१]शंकु षष्टि[६] गुणा[२]ध्वाहृता[३] मध्यात् ।
कोटि[४] प्रथक्[८]व्यसार्ये प्राच्यां प्राग[७]परयोः पश्चात्[५] ॥ ५९ ॥

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५८. (घ) १. माग्रो शंकुग्राह्याः (ग) मग्राशंक्वग्रयो for (मन्नाशंक्वग्रयोः)

२. सामान्यदिशोः for (सम्मान्यदिशोः)

३. दृज्ज्येकोटि (ग) करणौ दृग्येज्येकोटी for (करणोदग्ज्येकोटि)

४. वेशेषयदे for विशेषपदे)

(ग) ५. वाहुः for (बाहु)

(च) १. माग्राशंकुग्रह्योः for (मन्नाशंक्वग्रयोः)

२. सामान्यदिशोः for समान्यदिशोः)

३. दृज्येकोटी for (कोटि) ४. वशेषपदे for (विशेषपदे)

(क) १. मग्रासंक्क for (मन्नाशंक्वग्रयोः) २. दृश्यौ for (दिशोः) ३. कौटी for (कोटि)

५९. (घ) ३. गुणाव्याहृता हृतान्मध्यात् (ग) गुणान् व्यासदलहृतान् for (गुणाध्वाहृता मध्यात्)

३. कोटी पृथक् पृसार्ये (ग) कोटीपृथक् प्रसार्ये for (कोटि प्रथक्व्यसार्ये)

(ग) ६. शंकून् for (शंकु)

७. प्रागपरया; for (प्रागपरयोः)

(च) ३. गुणा व्याहृतान्मध्यात् for (गुणाध्वाहृतामध्यात्)

४. कोटी for (कोटि)

८. पृथक्पृसार्ये for (प्रथक्व्यसार्ये)

(क) १. काटिभुजर्ण for (कोटि भुजकर्ण) २. यष्टि (ग) for (षष्टि)

३. गुणात् व्यासिक्तात्म for (गुणाध्वाहृता मध्यात्)

४. क्वाऽग्रपृथक् प्रसयो for (कोटिप्रथक्व्यसार्ये) ५. मध्यात् for (पश्चात्)

कोटचग्राभ्यां बाहुकर्णे दिग्मध्यतो भुजाग्रांतौ ।
बाहुग्राह्यो स्वशंकुषष्टि मध्यान्तराग्रांते ॥ ६० ॥
दिग्मध्ये स्थित द्रष्टृचा पृथग् गृहौ दर्शयेत् स्वशंक्वग्रे ।
योगे शंक्वग्न्तरमंतरमथवान्यदाग्रहयोः ॥ ६१ ॥
नावार्यो ज्ञातेरपि तन्त्रैरार्यभटविष्णुचन्द्राद्यैः ।
यो ब्रह्मधूलिकर्म विदाचार्यत्वं भवति तस्य ॥ ६२ ॥

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६०. (घ) ४. ग्राह्या for (ग्राह्यो) (ग) बाहुग्रयोः for (बाहुग्राह्यो)
५. शंकूयष्टी (ग) for (शंकुषष्टि)
(ग) १. कर्णो for (कर्णे)
६. मध्यात्तदाग्रांते for (मध्यांतराग्रांते)
(च) ७. कोद्यग्राम्यां for (कोटचग्राभ्यां) बाहुकर्णौ for (बाहुकर्णे)
३. भुजाग्रांतो for भुजाग्रांतौ
४. बाह्वग्राह्यो for (बाहुग्राह्यो) ५. स्वशंकूयष्टी for (शंकुषष्टि)
६: मध्यांतराश्रांते for (मध्यांतराग्रांते)
(क) १. कणात् for (कर्णे) २. दृग् for (दिग्) ३. भुजाग्रातौ for (भुजाग्रांतौ)
४. बाह्वग्रयोः for (बाहुग्राह्यो) ५. यष्टि for (षष्टि)
६. मध्यत्तदग्रते for (मध्यांतराग्रांते)

६१. (घ) १. दृष्टृचा (ग) (च) for (द्रष्टृया)
३. शकूवयांतर (ग) शंक्वग्रांतर for (शंक्वग्रंतर)
(ग) ४. दिग्मध्यस्थित for (दिग्मध्येस्थित)
(च) ३. शंक्वग्रांतर for (शंक्वग्रन्तर)
(क) १. दृष्टृचा for (द्रष्टृया) २. ग्रहोदशयन्न for (ग्रहौ दर्शयेत्)
३. स्वस्वाप्रतिर्मततो सलभ्य for (शंक्वग्रन्तरमन्तर)

६२. (घ) १. न वार्यो (ग) नाचार्यो for (नावार्यो)
२. ज्ञातैरपि (ग) (च) for (ज्ञातेरपि)
३. ब्राह्मधूलि (च) ब्राह्मधूलिकर्म्म for ब्रह्मधूलिकर्म)
(ग) ४. राचार्यभट for (रार्यभट)
(क) १. नाचार्यौ for (नावार्यो) २. जातै for (ज्ञातेरपि) ३. ब्राह्म for (ब्रह्म)

रविशशितमस्त्रिवरितं[1] ब्रह्मोक्तं पुण्यमङ्गुतं ज्ञात्वा[4] ।
रविचन्द्रराहु लोकात्[2] प्राप्नोति पुमानीह[3] यशश्च ॥ ६३ ॥
अन्यैरप्यूक्तमिदं[4] योयं सम्यक्[5] ग्रहं[1] विजानाति ।
याति सद्दरलोकं[2] ग्रहाष्टकज्ञं[3] परं ब्रह्म[4] ॥ ६४ ॥
मध्यमगतिः[4] स्फुटगति[5] स्त्रिप्रश्नश्चन्द्र[6]भास्कर[1] ग्रहणे ।
उदयास्तमय[2]प्रतिघटिकामिदोः[3] शृङ्गोन्नतिछाये ॥ ६५ ॥

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६३. (घ) १. तृवरितं (ग) तमस्त्रिचरितं for (तमस्त्रिवरितं)
३. पुमानिह (च) for (पुमानीह)
(ग) ४. श्रुत्वा for (ज्ञात्वा)
२. लोकान् for (लोकात्)
(च) १. तमसृचरितं for (तमस्त्रिचरितं)
(क) १. चरितं for (वरितं) २. लोकान् (ग) for (लोकात्)
३. पुमानिह (ग) for (पुमानीह)
६४. (घ) ४. अन्यैरप्युक्तमिदं (ग) (च) for (अन्यैरप्यूक्तमिदं)
५. सम्य (ग) सम्यग्ग्रहं for (सम्यक्ग्रहं)
२. सतद्ग्रहलोकं (ग) (च) for (सद्दरलोकं)
३. ग्रहाष्टज्ञः (ग) ग्रहाष्टकज्ञः for (ग्रहाष्टकज्ञं)
(ग) ४. ब्रह्मः for (ब्रह्म)
(च) ५. सम्यग्रहं for (सम्यक्ग्रहं)
३. ग्रहाष्टकज्ञः for (ग्रहाष्टकज्ञं)
(क) २. सतग्रह for (सद्दरलोकं)
३. ग्रहाष्टज्ञः for (ग्रहाष्टकज्ञं)
६५. (घ) १. भास्करं (च) for (भास्कर)
२. उदयास्तमयः (ग) उदयास्तमयौ for (उदयास्तमय)
३. प्रतिघटिकर्मिदो (ग) प्रतिघटिकर्मिदु for (प्रतिघटिकामिदोः)
(ग) ४. मध्यगतिः for (मध्यमगतिः)
५. स्पष्टगति for (स्फुटगति) ६. त्रिप्रश्नचन्द्र for (त्रिप्रश्नश्चन्द्र)
(च) २. उदयास्तमयः for (उदयास्तमय) ३. प्रतिघटिकर्मिदो for (प्रतिघटिकामिदोः)
(क) १. मध्यमगतिस्त्रिप्रश्नश्चंद्र भास्कर ग्रहणे । उदयास्तमयः । चंद्रग्रहणं चतुर्थः सूर्यग्रहणं पचमः । उदयास्तमय षष्टाप्रति घटिका मिंदोः शृंगोन्नति छाये । for (मध्यमगतिः स्फुटगतिस्त्रिप्रश्नश्चन्द्रभास्करग्रहणे । उदयास्तमय प्रतिघटिकामिदोः शृङ्गोन्नतिछाये ।)

ग्रहयोगोत्र ग्रहयुतिरार्यात्रिशति युताष्ट सप्तत्या ३७८
अध्यायैर्दशभिर्धू लिकर्म वोच्चैर्विना ब्रह्मं ॥ ६६ ॥
गुरुणा नधूलिकर्म प्रतिकंचुककारिणे प्रदातव्यम् ।
दत्त सुकृतप्रणाशं कुरुते प्रतिकंचुकं यस्य ॥ ६७ ॥
गृहमेलके यदुक्तं तत्स्थूलं स्पष्टमिह यदुक्तं तत् ।
गृहभमुनींदु छाया शृङ्गोन्नतिभोदयाद्येषु ॥ ६८ ॥
सूर्यास्तमयादिष्टाद्रातिगताच्छेष्ट भोदयास्तमयौ ।
जानाति न कश्चिदपि ब्राह्मनं मुच्चान्यतन्भज्ञः ॥६९॥

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६६. (घ) १. भ (ग) (च) for (त्र)
(ग) ३. त्रिशती for (त्रिशति)
४. चाद्यै for (वोच्चै)
(च) ५. ईशभि for (दशभि) ६. धूलिकर्म्म for (धूलिकर्म)
(क) १. भ for (त्र) २. ब्राह्मी (ग) ब्राह्म्ये for (ब्रह्मं)

६७. (घ) ३. योस्य (ग) (च) for (यस्य)
(ग) १. प्रतिकंचककारिणे for (प्रतिकंचुककारिणे)
४. सुकृतः प्रणाशः for (सुकृतप्रणाशः)
(च) ५. कर्म्म for (कर्म)
(क) १. प्रातस्थकुंक कारिणो for (प्रतिकंचुककारिणे)
२. सुकं योस्या for (चुकंयस्य)

६८. (घ) १. ग्रेहभमुनींदु (ग) for (ग्रहभमुनींदु)
(ग) ३. स्पष्टमिदं for (स्पष्टमिह)
(च) ५. तस्थूलं for (तत्स्थूलं)
(क) १. ग्रहण मनींदुछायो for (ग्रहभमुनींदुछाया) २. लोदयाद्येषु for (भोदयाद्येषु)
४. ग्रहामलके for (ग्रहमेलके) ३. स्पष्ट इह for (स्पष्टमिह)
यह यहीं समाप्त है ।

६९. (घ) १. दिष्ट्याद्ग्रारिगता for (दिष्टाद्रातिगता) (ग) सूर्यास्तमयाद्वारात्रिगता for (सूर्यास्तमयादिष्टाद्रातिगता)
२. द्वेष्ट (ग) स्वेष्टभोदयास्तमयोः for (छेष्टभोदयास्तमयौ)
३. ब्राह्मं मुत्वान्यतंत्रज्ञः (ग)ब्राह्मं मुक्तान्यतंत्रज्ञः for (ब्राह्मनं मुचान्यतन्भज्ञः)
(क) यह श्लोक उपलब्ध नहीं,
(च) १. दिष्ट्याद्ग्रारिगता for (दिष्टाद्रातिगता) २. द्वेष्ट for (छेष्ट)
३. ब्राह्मं मुचान्यतंत्रज्ञः for (ब्राह्मनंमुचान्यतंत्रज्ञः)

भमुनी[1]ध्र व विक्षेप गृहोदयास्त मयना[3]डिकाद्येषु ।
अध्यायोभगृह युतिरार्याणां सप्तति दश[2] ।। ७० ।।
[4]इत्ति ब्रह्मगुप्ते दशमोऽध्यायः ।।
इति श्री ब्राह्मस्फुटसिद्धान्ते ग्रहतारादिक्षेपाधिकारोदशमः ।। १० ।।
सम्पूर्णा पूर्वादशाध्यायी

७०. (घ) १. भमुनि (ग) (च) for (भमु)

२. दशमा for (दश)

(ग) ३. कालिकाद्येषु for (नाडिकाद्येषु)
आर्याणां सप्तत्या दशमोभग्रहयुतिरध्यायः ।। ७० ।।
इति श्री ब्रह्मगुप्ताचार्य विरचिता दशाध्यायी समाप्ता ।।
for (अध्यायोभग्रहयुतिरार्याणां सप्ततिर्दश ।।७०।। इति ब्रह्मगुप्ते दशमोऽध्यायः)

(क) यह श्लोक उपलब्ध नहीं है।

(च) २. ईश for (दश)
४. 'इति' से 'अध्यायः' तक लुप्त

(ग) वि०-अतिरिक्त पाठ—
इति श्री ब्रह्मगुप्ताचार्य विरचिता दशाध्यायी समाप्ता । अथ स्वस्ति श्री संवत् १६७७ वर्षे शाके १५४३ प्रवर्तमाने ।। ज्येष्ठबदि १० सोमे । रेवती घटी १८ पल १७ नक्षत्रे । अत्र ग्रन्थ लिषित समये श्री राजनगर मध्यवास्तव्यं ।श्री······ज्ञातीय । ज्योति श्री ···कस्य इयं पुस्तिकालिषितमस्ति । उक्तं च । याद्रिशं पुस्के द्रिष्टवा ताद्रिशं लिखितं मया । यदिशुद्धम-शुद्धं वा मम दोषो न दीयते ।। पुनः ।। भग्नहष्टि कटिग्रीवाबद्धमुष्टिरधोमुखम् । कष्टेन लिखितं शास्त्रं यत्नेन परिपालयेत् । लेषकपाटकयोः शुभं भवतु । स्वयं पठनार्थं तथापुत्रपौत्रादिपठनार्थं । परोपकारार्थं । श्री कृष्णार्पणमस्तुः ।। श्रीरस्तु मंगल मस्तु । शुभंभवतु । जयोस्तु । छः छः छः छः छः छः । उक्तं च । ब्रह्मा प्राह त नारदाय हिमगुर्य शौनकायालं मांडव्याय वसिष्ठसंज्ञकमुनिः सूर्यामियायं हिं यत् । सत्पक्षागमशास्त्र युक्तममिदं शास्त्रं विहायान्यथा । ये कुर्वंति नरान् निर्वहति तो विज्ञानशून्याश्चिरम् ।।

अथ तन्त्र परीक्षा नामैकादशोध्यायः

ये[1] ज्ञान पटलरु[2]द्धदशोन्यब्रह्मा[3]द्वदन्ति सिद्धान्तम्[4] ।
तेषां युगादिभेदेद्ये[5] दोषास्तान्प्रवक्षा[6]मि ।। १ ।।
युगमाहुः पञ्चाब्दं[1] रविशशिनोः संहितांग का[3]रये ।
अधिमासा वमरात्र स्फु[4]टतिथ्यज्ञान तदस[2]त् ।। २ ।।

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१. (घ) १. येऽज्ञान for (ये ज्ञान)
२. रुद्धद्दशो (ग) रुद्धदशो for (रूद्धदशो)
३. न्यद्बाह्याद्वदन्ति (ग) ऽन्यद्ब्राह्याद्वदन्ति for (न्यब्रह्माद्वदंति)
४. सिद्धांतात् (ग) (च) for (सिद्धान्तम्)
५. भेदाद्ये (ग) (च) for (भेदेद्ये)
६. प्रवक्ष्यामि (ग) प्रविक्ष्यामि for (प्रवक्षामि)

(च) २. रुद्धद्दशो for (रूद्धदशो)
३. द्ब्राह्याद्वदन्ति for (ब्रह्माद्वदन्ति) ४. सिद्धान्तात् for (सिद्धान्तम्)
६. प्रवक्ष्यामि for (प्रवक्षामि)

(ग) वि०-अतिरिक्त पाठ—
अथ ब्रह्मगुप्तसिद्धांते एकादशमोऽध्यायः प्रारभ्यते ।। खखखार्क १२००० द्वृताब्देभ्यो गतगम्याल्पा-त्खशून्य यमल । २०० हृतात् । लब्धं त्रि ३ सायक हतं कलाभिरूनौ सदार्केंदू ।। १ ।। विधु वज्जीवेद्वि २ हतं चन्द्रोच्चं तिथि १५ गुणं च सितशीघ्रे ।। द्वीषु ५२ हतं च स्वांर द्वि २ कु १ वेद ४ हतं च पात कुजशनिषु ।। २ ।। ग्रहबीजानि ब्रह्मसिद्धांते ।।

२. (घ) १. पंचाक्षरं for (पञ्चाब्दं)
२. ज्ञानतस्तदसत् (ग) तस्तदसत् for (ज्ञानतदसत्)

(ग) ३. —-रयै for (कारये)
४. स्फुतिथ्य for (स्फुटतिथ्य)
५. ज्ञान् for (ज्ञान)

(च) ३. काराय for (कारये)

भानि ध्रुवपं[1]चाशत् द्वा[4]वर्कादयो जिनोक्तं यत् ।
ध्रुवम [2]सस्यावर्णो भवति [3]यतोह्ला ततो सतत् ॥ ३ ॥
[1]आर्यभटो युगपादांस्त्रीन् [4]पातानाह कलियुगादौ यत् ।
३२४०००० तस्य कृतां त[2]र्यस्मात् स्वयुगाद्यंतौ न [3]तस्मात् ॥ ४ ॥
रवि[4]युगभगणां र[5]व्युधृति [1]४३२०००० यत्प्रोक्तं त[2]त्रयो[6]र्युगं [3]स्पष्टम् ।
त्रिशतीरव्युदयानां तदन्तरं हेतुना केन ॥ ५ ॥[7]

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३. (घ) १. पंचांशत् for (पंचाशत्) (ग) चतुः पंचाशत् द्वौ for (ध्रुवपंचाशत् द्वा)
२. ध्रुवमत्सस्या (ग) ध्रुवमत्सस्यावर्त्तो for (ध्रुवमसस्यावर्णो)
३. यतोह्ला ततोसत्तत् (ग) for (यतोह्लाततो सतत्)

(च) ४. द्वावर्क्कादियौ for (द्वावर्कादयो)
२. ध्रुवमत्सस्यावर्णों for (ध्रुवमसस्यावर्णो)
३. यतोह्ला ततो सत्तत् for (यतोह्ला ततो स तत्)

४. (घ) १. अर्यभटो for (आर्यभटो) (ग) आर्यभटोसुत for (आर्यभटोयुग)
२. यस्मात्तं for (र्यस्मात् स्व)
३. तत्तस्मात् (ग) for (न तस्मात्)

(ग) ४. यतोनाह for (पातानाह)

(च) १. अर्यभटो for (आर्यभटो)
३. न तत्तस्मात् for (न तस्मात्)

५. (घ) १. ४३२००० (च) for (४३२००००)
२. तंत्रयौ for (तत्रयो)
३. स्पष्टान्यत् for (स्पष्टम्)
वि०—इस श्लोक की दूसरी पंक्ति यहां लिपिकार लिखना भूल गया प्रतीत होता है। यही नहीं छठे श्लोक की पहली पंक्ति भी यहां लुप्त है।

(ग) ४. युगरविभगणाः for (रवियुगभगणां)
५. रव्युद्रिति for (रव्युधृति)
६. युगं for (र्युगं)
७. +३०० ॥०॥+

(च) १. ४३२०० यत्पोक्तं for (४३२००००

युगवर्षादिनवदच्चैत्र सितादेः समं प्रवृत्तान्यत् ।
तदसत् यतः स्फुटयुगं तस्छैर्यान्मिंदपातानाम् ॥ ६ ॥
ग्रहभुक्त रूनाया मंदोच्चं भवति शीघ्रमधिकायाम् ।
उच्चगतौ मंदोच्चवं न विना भुक्तेंदु वर्जमेतः ॥ ७ ॥
आर्याष्टशते पाता भ्रमंति दशगीतके स्थिराः पठिताः ।
मुक्तेंदुपातमंडपमण्डले भ्रमति स्थिरानातः ॥ ८ ॥
आर्यभटो जानाति गृहाष्टाति यदुक्तवांस्तदसत् ।
राहुकृतं न गृहणं तत्पातो नाष्टमो राहुः ॥ ९ ॥

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६. (घ) यहां श्लोक का पूर्वार्ध लुप्त है।
१. तदराज् (ग) तदसद्युतः for (तदसत्—तदसत् यतः)
२. तत्स्थैर्यान् (ग) स्थैर्यान् for (तस्छैर्यान्)
(ग) ३. युगवर्षादी for (युगवर्षादि)
४. सप्रवृत्तानयत् for (समं प्रवृत्तान्यत्)
५. युतं गं न for (युगं)
७. (घ) १. रूनायां for (रूनाया)
२. भुतय न्दु for (भुक्तेंदु)
३. वर्जमतः for (वर्जमेतः)
(ग) ४. परिधि फले व्यावहारिके त्रिगुणे for (मंदोच्चं भवति शीघ्रमधिकायाम्)
५. दूसरी पंक्ति बिल्कुल भिन्न है—
'तद्वर्गाभ्यां दशभिः संगुणिताभ्यां सूक्ष्मे'

वि०—तीसरी पंक्ति यह है—
उच्चं भवति शीघ्रमधिकायां । उच्चगतौ मंदोच्चं न विना भुक्त्येंदुवर्ज्मनः ॥७॥
अर्थात् रेखांकित दो पंक्तियां अधिक हैं।
८. (घ) १. आर्याऽष्टशते (च) for (आर्याष्टशते)
२. दशगीतेके (ग) दशगीतिके for (दशगीतके)
३. मुक्त्वेन्दु (ग) for (मुक्तेंदु)
४. भ्रमंति (ग) for (भ्रमति)
(ग) ५. मपमंडले for (मंडपमण्डले) (च)
(च) २. दश२गीतके for (दशगीतके)
९. (घ) १. ग्रहाष्टकर्गाति (ग) for (ग्रहाष्टाति)
२. तस्पातो (ग) तस्यातो for (तत्पातो)

न समा[3]युगमनुकल्पाः कल्पादिगत[1] कृतादियातं च ।
स्मृत्युक्तै[2]रार्यभटो ना तो जानाति मध्यगतिं ॥ १० ॥
उँकारो[1] दिनवारो[3] गुरुरदयिकोस्य[2] भवति कल्पादौ ।
न भवत्यर्को[4] यस्मादोंकारे विस्वरस्तस्मात् ॥ ११ ॥
सूर्योदयाच्चतुर्थात्[1] दिनपात्[2] यदुवाच तदसदार्यभटः[3] ।
लंकोदयो[4] यतोर्क[5] स्यास्तमयं प्राह सिद्ध पुरे ॥ १२ ॥
आधिकैः[1] शतैश्चतुर्भिवर्ष[2] सहस्त्रैश्चतुर्दशाभिरेकः[3] १४४०० ।
युगपातै[5]र्दिनवारोत्तर[6]योदयिकर्द्ध[4] रात्रिकयोः ॥ १३ ॥

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१०. (घ) १. कल्पादिगतं (ग) (च) for (कल्पादिगत)
२. स्मृत्युक्तैर्यभटो for (स्मृत्युक्तैरार्यभटो)
(ग) ३. समायुतं गमनुकल्पाः for (समायुगमनुकल्पाः)

११. (घ) १. ओंकारो for (उँकारो)
२. रौदयिको (ग) रोदयिक्येस्य for (रदयिकोस्य)
(ग) ३. दिनचरै for (दिनवारो)
(च) २. गुरुरौदयिको for (गुरुरदयिको)
४. न भवत्यर्क्को for (न भवत्यर्को)

१२. (ग) १. चतुर्थान् for (चतुर्थात्)
२. दिनपान for (दिनपात्)
३. तव for (तद)
४. लंकोदये for (लंकोदयो)
५. यतोर्क्क स्या for (यतोर्कस्या)

१३. (घ) १. अधिकैः (ग) (च) for (आधिकैः)
२. चतुर्भिर्वर्ष (ग) (च) for (चतुर्भिवर्ष)
३. चतुर्दशभिरेकः (ग) (च) for (चतुर्दशाभिरेकः)
४. मौदयिकार्द्ध (ग) for (योदयिकर्द्ध)
(ग) ५. युगजातै for (युगपातै)
६. र्दिनवारोत्तर for (र्दिनवारोत्तर)
(च) ४. मोदयिकर्द्ध for (योदयिकर्द्ध)

उदयिकाद्दिन[1] भुक्तचार्द्ध[2] रात्रिको मध्यमोभवेत्[3] पूतः ।
कतरं[4] स्फुटं न निश्चितमनयोः[5] स्फुटमेकमपि नातः[6] ॥ १४ ॥
षोडशगिरियिवि[1] योजन परिधि षडम्दव्यासं[2] पुनर्लाविदता[3] ।
आत्मज्ञानं[4] ख्यापितमनिश्चयः स्वमतिकृतकत्वात् ॥ १५ ॥[4]
भुव्यासस्य[1] ज्ञाना[2] ध्व्यर्थं देशांतरं दज्ञानात्[3] ।
स्फुटतिथ्यंताज्ञान[4] तिथिनाशाद् गृहण्योनाशः[5] ॥ १६ ॥

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१४. (घ) १. औदयिकाद्दिन (ग) औदयिकादिन for (उदयिकाद्दिन)
२. भक्तचार्द्ध for (भुक्तचार्द्ध)
३. भवत्पूनः (ग) (च) for (भवेत्पूतः)
४. कतरत् (ग) कतर for (कतरं)
५. निश्चत for (निश्चित) (च)

(ग) ६. मतिनातः for (मपिनातः)

(च) १. औदयिकाद्दिन for (उदयिकाद्दिन) ४. कतरत् for (कतरं)

१५. (घ) १. षोडशगिरियियोजनपरिधि (ग) षोडासगिरियियोजनपरिधि for (षोडशगिरियिवियोजन परिधि)
२. षडि भूव्यासं (ग) निभूव्यासं for (षडम्दव्यासं)
३. पुनर्जिलावदता (ग) पुना लावदता for (पुनर्लाविदता)
४. आत्माज्ञानं (ग) (च) for (आत्मज्ञानं)

(च) २. षड्भिभूव्यासं for (षडम्दव्यासं)
३. पुर्नकिलावदता for (पुनर्लाविदता)
४. यहाँ क्रमसंख्या लुप्त है ।

१६. (घ) १. भूव्यासस्या (ग) (च) for (भुव्यासस्य)
२. ज्ञानाद्व्यर्थं (ग) (च) for (ज्ञानाध्व्यर्थं)
३. तदज्ञानात् (ग) for (दज्ञानात्)
४. ज्ञानम् (ग) for (ज्ञान)
५. नाशाद्ग्रग्रण्योर्नाशः (ग) for (नाशाद्ग्रहण्यो नाशः)

(च) ५. नाशाद्ग्रग्रण्योर्नाशः for (नाशाद्ग्रहण्यो नाशः)

प्राणेनैतिकला[१]भूर्यदि[५] तत्ककुतो[२] व्रजेत्किमध्यानम् ।
आर्वतनमुर्व्याश्चे[६]त्त[३] पतंति समुछ्रयः[४] कस्मात् ।। १७ ।।
उदयिके[१] यः परिधिर्विषमोन्योन्य[२] समेन्यभुजस्य गुणः[३] ।
तदसद्विषमांतफलं यतोन्य[५]युग्मादि[४] फल तुल्यम् ।। १८ ।।
विषमोन्योन्ये[१] युग्मे[२] परिधिर्गुणकः क्रमोक्रमाद्यानाम्[३] ।
चक्रार्द्धे फलनाशो न भवति यस्मादसत्तदपि ।। १९ ।।
व्यासार्द्धहतो[२] बाहुः परिधिविशेषाहतः फलोनयुतः ।
प्रथमोधिकोनकोय[३] तदसत्पदयोः[१] परिधिपाठात् ।। २० ।।

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१७. (घ) १. कलां (ग) (च) for (कला)
२. तत्कत्कुतो (ग) तत्क्व कुतो (तत्ककुतो)
३. चेन्न for (चेत्त)
४. समुछ्रृयः (ग) समुछ्रयाः for (समुछ्रयः)
(ग) ५. भूयदि for (भूर्यदि)
६. आवर्तनमुर्व्याश्चेन्न (च) for (आर्वतनमुर्व्याश्चेत्त)
(च) ४. समुछ्रयः for (समुछ्रयः) २. तत्क्वकुतो for (तत्ककुतो)

१८. (घ) १. औदयिके (ग) (च) for (उदयिके)
२. द्विषमेन्योन्य (ग) विषमेन्योन्यः for (विषमोन्योन्य)
३. समे भुजस्य गुणः (ग) समे भुजस्य गुणाः for (स मेन्यभुजस्य गुणः)
४. यग्मादि for (युग्मादि)
(ग) ५. यतोन for (यतोन्य)
(च) २. र्विषमे for (विषमो) ३. समे भुजस्य for (समेन्यभुजस्य)

१९. (घ) १. विषमे (ग) (च) for (विषमो) २. न्यो (ग) for (न्योन्ये)
३. क्रमोत्क्रमज्यानाम् (ग) for (क्रमोक्रमाद्यानाम्)
(च) १. विषमेन्योन्योयुग्मे for (विषमोन्यान्ये युग्मे)
३. क्रमोत्क्रमाद्यानां for (क्रमोक्रमाद्यानां)

२०. (घ) १. कोयत्तदसत् for (कोयतदसत्) (ग) २. हतौ for (हतो)
(च) २. हतो for (हतो) १. यत्तदसत्पदयोः for (यतदसत्पदयोः)

विषमसमयोर्यदि द्वौ परिधि[1] किं सूर्य चन्द्रयोर्नोक्तौ[2] ।
घटते न कथंचिदियं स्फुटक्रियोदयिकतन्त्रोक्ता ॥ २१ ॥
उत्तरगोले[2] ग्रायां विषुवद्यातो[3] यदुक्तमुनायाम्[1] ।
सममंडलगस्तदसत् क्रान्तिज्यायां यतो भवति ॥ २२ ॥
व्यासार्द्धेन[3] भविभक्ता दग्गतिजीवा[2] चतुर्गुणा[4] लब्धम् ।
लंबननाड्यः[1] पंचदशगुणितया त्रिज्यया भक्ताः[5] ॥ २३ ॥
दृक्षेपज्या भुक्तितरा[2]हता[1] लब्धमवनतिर्भवति ।
स्फुटयोजनकर्णाभ्यां भूव्यासार्द्धेन[3] च विना स्पष्टे ॥ २४ ॥
आर्यभटेनास्मि[1] मतिलघुनि[4] किमर्थं महत्कृतं कर्म[2] ।
गणिताज्ञाना[5]जाड्यं[3] विजानयता[6] यदि ततः सुतराम् ॥ २५ ॥

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२१. (घ) १. परिधी (ग) (च) for (परिधि)
२. योर्नोक्तौ (ग) योनोक्तौ for (योर्नोक्तौ)

२२. (घ) १. मूनायाम् (ग) (च) for (मुनायाम्)
(ग) २. गोणे for (गोले)
३. ज्यातो for (द्यातो)

२३. (घ) १. ताड्यः for (नाड्यः) २. दृग्गति (ग) दृगाति for (दग्गति)
(ग) ३. 'भ' लुप्त है।
४. चतुगुणा for (चतुर्गुणा)
५. भक्ता for (भक्ताः)
(च) २. दृग्गति for (दग्गति)

२४. (घ) १. तराद्धिता for (तराहता)
(ग) २. भुक्त्यंतरा for (भुक्तितरा)
३. भूव्यासे for (भूव्यासार्द्धेन)
(च) १. हृता for (हता)

२५. (घ) १. आर्यभटेनास्मिं सति (ग) आर्यभटेनास्मि न सति for (आर्यभटेनास्मिमति)
२. कर्मः for (कर्म)
३. ज्जाड्यं for (जाड्यं)
(ग) ४. लघुति for (लघुनि)
५. ज्ञातानाज्जाड्यं for (ज्ञानाजाड्यं)
६. विजानता for (विजानयता)
(च) २. कर्म्म for (कर्म)

लंबनमृणधनमुक्तं पूर्वापर[3]योस्तिथौ दिनार्द्धस्य ।
युक्तो भावो यद्भवति तद्दणधनयोस्थि[1]थोक[2]धरम् ।। २६ ।।
[1]दृग्क्षेपज्या बाहु [3]दृग्ज्याकर्णोनयोः [2]क्तितिशेषात् ।
मूलंदृग्गतिजीवा संस्थानमयुक्तमेतदपि ।। २७ ।।
लंबनघटिका लिप्ता [1]दृशज्ययार्केंदु[4]दृग्गतिकलानाम् ।
[3]यस्मान्न [2]समस्तस्मात् [5]दृशज्यया लंबनं स्थूलम् ।। २८ ।।
वित्रिभलग्ने दृक्षेप[1]मंडलयुतो[2] ज्या [3]मध्या ।
मध्या[5]दृक्षेपज्यानार्य[4]भटोक्तनया तुल्या ।। २९ ।।

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२६. (घ) १. स्थितौ (ग) for (स्तिथौ)
२. कतरत् (ग) for (कधरम्)
(ग) ३. पूर्वापरास्थितौ for (पूर्वापरयोस्तिथौ)
(च) १. स्तिथोकतरत् for (स्थिोकधरम्)

२७. (घ) १. दृक्षेपज्या (ग) क्षेपज्या for (दृग्क्षेपज्या)
२. कृतिविशेषात् for (क्तितिशेषात्)
(ग) ३. दृंगत्या for (दृग्ज्या)
२. कृतिविशेषात् (च) for (क्तितिशेषात्)
(च) १. दृक्षेपज्या for (दृग्क्षेपज्या) ५. दृंग्ज्या for (दृग्ज्या)

२८. (घ) १. दश (ग) द्रश for (दृश)
२. समा (च) for (सम)
(ग) ३. यस्मा समास्तस्मा for (यस्मान्न)
(च) १. दशज्ययार्कंदु for (दृशज्ययार्केंदु)
४. द्रग्गति for (दृग्गति) ५. दशज्यया for (दृशज्यया)

२९. (घ) १. मंडलं तदप (ग) मंडलं तप तदप for (मंडल युतो)
२. युतौ (ग) for (युतो)
३. (लुप्त)
४. भटोक्तातया (ग) for (भटोक्तनया)
(च) ३. "मध्या" लुप्त ५. दृक्ष्येपज्या for (दृक्षेपज्या)
४. भटोक्ता तया for (भटोक्तनया)

दृक्षेपज्यातो सत्तन्नाशादवनते भवति[४] ।
नाशः[१] अवनतिनाशा[५]द्ग्रामस्यो[२] नाधिकवार[३] विगृहणे ॥ ३० ॥
पंचज्यया यतोर्क[३]गृहणं श्रीषेणविष्णुचन्द्रकृतम्[१] ।
आर्यभटोक्तान्यनयोरर्क[४] गृह दुषणानि[२] ततः ॥ ३१ ॥
एवं विचार्यमाणं पंचज्यालम्बनं महास्थुलम्[१] ।
स्थुलावनतिश्च[२] तथा दृशज्यया[४] लंबनावनति[३] ॥ ३२ ॥
नाडीचुतुष्टु[१]विधिना सर्वत्रसमो यतस्तत स्थुलः[२] ।
मानार्थ[३]कर्ममहत्कृत्[४] मार्यभटेन लघुनि सति ॥ ३३ ॥

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३०. (घ) १. पहली पंक्ति का अंतिम शब्द 'नाशः' ।
२. नाशाद्ग्रासस्यो for (नाशाग्रामस्यो)
३. नाधिकता रवि for (नाधिकवारवि)
(ग) ४. भवति नाशः for (भवति)
५. दूसरी पंक्ति का आरम्भ 'अवनतिनाशाद्ग्रासस्यो ना'
(च) २. नाशाद्ग्रासस्यो for (नाशाग्रामस्यो)

३१. (घ) १. विष्णु चं कृतं for (विष्णुचन्द्रकृतम्)
२. दूषणानि (ग) for (दुषणानि)
(च) ३. यतोर्क्क for (यतोर्क) १. चन्द्रकृतं for (चन्द्रकृतम्)
४. रर्क्क for (रर्क)

३२. (घ) १. स्थूलं (ग) माहास्थूलं for (महास्थुलम्)
२. स्थूलाऽवनतिश्च (ग) for (स्थुलावनतिश्च)
३. वनती (ग) चनती for (वनति)
(च) १. महास्थूलं for (महास्थुलम्)
२. स्थूलावनतिश्च for (स्थुलावनतिश्च)
४. दशज्यया for (दृशज्यया)
३. लंबनावनती for (लंबनावनति)

३३. (घ) १. चतुष्क (ग) (च) for (चुतुष्टु)
२. स्थूलः (ग) (च) for (स्थुलः)
३. मानार्थं (ग) (च) for (मानार्थ)
४. महत्कृत (ग) (च) for (महत्कृत्)

विक्षेपगुणाक्षज्या लंबकभक्ता गृहे मृणधनं यत् ।
उत्क्रमुदयास्तसमयोर्न्नं प्रतिघटिकं ततस्तदसत् ॥ ३४ ॥
त्रिज्या कृत्या भक्ता विक्षेपापक्रमगुणो क्रमज्येंदोः ।
अयनांतेमृणधनं न तदयनादौ ततौ सा तत् ॥ ३५ ॥
दक्कर्ण विज्ञानात् कालाविज्ञानमकथितत्वाच्च ।
कालज्ञानाच्छंकोरज्ञानं कोटिनाशोतः ॥ ३६ ॥
शशिशंकोः शच्यपराकोटिभुजवर्गयुतिमूलम् ।
तिर्यक्कर्णो न भवति यतो चन्द्रांतरं कर्णः ॥ ३७ ॥

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३४. (घ) १. गुण for (गुणा)
२. गृहे (ग) ग्रहेष्वृण for (ग्रहे)
३. मययो (ग) for (समयो)
(ग) ४. ध्या for (ज्या)
५. नंम्रतिघटिकं for (र्न्नंप्रतिघटिकं)
(च) १. गुणाक्ष्यज्या for (गुणाक्षज्या) २. गृहे for (ग्रहे)

३५. (घ) १. यद्दण (ग) (च) for (मृण)
२. ततो (ग) for (ततौ)
३. सत्तत् (च) for (सातत्)
(ग) ४. विक्षेपायनगुणोत् for (विक्षेपापक्रमगुणो)
५. तत्तस्यादौ for (नतदयनादौ)
(च) ६. क्रत्या for (कृत्या) ७. गुणोत्क्रम for (गुणोक्रम)

३६. (घ) १. दक्कर्मा (ग) (च) for (दक्कर्ण)
२. विज्ञातात् for (विज्ञानात्)

३७. (घ) १. प्राच्य (ग) (च) for (शच्य)
२. कोटिकोठि (ग) कोटिः कोटि for (कोटि)
३. यंतोर्कचंद्रांतरं (ग) for (यतोचंद्रांतरं)
(ग) ४. वर्ग्र for (वर्ग)
(च) ३. यंतो for (यतो)

कोटिश्रवण[३]ज्ञानात्[१] शशिना श्रृङ्गोन्नतिर्विसंवदति[४] ।
उदयास्तमयो दिनकृतः[५] प्रतिघटिकं[२] माती च वाज्ञानात् ॥ ३८ ॥
अर्केन्द्वतर[१]घटिका व्यस्तज्या चन्द्रमानगुणिता[३] यत् ।
व्यास विभक्ता शुद्धं[४] यतो न द्रक्[२] सममसत्तस्मात् ॥ ३९ ॥
प्राक् गुदितोभ्यधिकः[१] पश्चादुदिनकोयरेव्यस्तः[२] ।
कालो यः[३] छायार्थं तदसत्स्फुटभुक्तिमान्[४] प्राक् ॥ ४० ॥
उदितामुदितास्तमितावशेषकालान्न[१][२] वेत्ति यः स कथम् ।
आर्यभटज्ञः शशिनः[३] छाया श्रृङ्गोन्नति[४] वेंति[५] ॥ ४१ ॥

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३८. (घ) १. ज्ञाना छशिन for (ज्ञानात् शशिना) (ग) छशिनः for (शशिना)
२. प्रतिघटिकमतीव वा ज्ञानात् (ग) प्रतिघटिकमतीव चाज्ञानात् for (प्रतिघटिकं माती च वा ज्ञानात्)
(ग) ३. श्रवणा for (श्रवण)
४. विसंवदतिः for (विसंवदति)
५. दिनकृतः for (दिनकृतः)
(च) १. ज्ञाना छशिना for (ज्ञानात् शशिना)
२. प्रतिघटिकमती च for (प्रतिघटिकं माती च)
३९. (घ) १. अर्क्केद्वंतर (ग) (च) for (अर्केद्वतर)
२. द्दक्सम (ग) (च) for (द्रक्सम)
(ग) ३. गुणिना for (गुणिता)
४. शुक्लं (च) for (शुद्धं)
४०. (घ) १. प्राक्य्गुदितोऽम्यधिकः (ग) प्राक् प्रागुदितोभ्यधिकः for (प्राक् गुदितोभ्यधिकः)
२. दुदितो न कोपरे व्यस्तः (ग) (च) for (दुदिनकोयरे व्यस्तः)
३. कालो छायार्थं (ग) कालौ य स्थार्यर्थं for (कालो यः छायार्थं)
४. भुक्तिमानात् प्राक् (ग) भुक्तिगमना प्राक् for (भुक्तिमान् प्राक्)
(च) १. प्राक्यगुदितोऽम्यधिकः for (प्राक् गुदितोभ्यधिकः)
४१. (घ) १. नुदिता (ग) (च) for (मुदिता)
२. कालान for (कालान्न)
३. शशिन (ग) शशिनस्छाया for (शशिनः छाया)
४. श्रृंगोन्नती (ग) (च) for (श्रृङ्गोन्नति)
५. वेत्ति (ग) (च) for (वेंति)
(ग) ३. शशिन for (शशिनः)

स्वयमेव नामय [1]कृतमार्यभटेन स्फुटं स्वगणितस्य ।
[2]सिद्धांतदस्फुटत्वं [3]ग्रहणार्दानां [4]विसंवदति ॥ ४२ ॥
[1]जानात्येकमपि यतो [4]नार्यभटोगणित[5]कालगोलानाम् ।
न मया [2]प्रोक्तोनि ततः पृथक् पृथक् [3]दुषणात्येषाम् ॥ ४३ ॥
आर्यभट[1]दुषणानां संख्या वक्तुं न शक्यते यस्मात् ।
तस्मादय[2]मुद्दे श्यो बुद्धिमतान्यानि योज्यानि ॥ ४४ ॥
[3]कालांतरेण दोषा येन्यैः प्रोक्ता न ते मयाभिहिताः ।
किं ते [1]दूष्येष्वथ [4]दूषकेषु कोशोऽत्र पेयः [2]स्थात् ॥ ४५ ॥
श्रीषेणविष्णुचन्द्रप्रद्युम्नार्यभटलाटसिंहानाम् ।
ग्रहणादिविसंवादात् प्रतिदिवसं सिद्धम[1]कृत्वम् ॥ ४६ ॥

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४२. (घ) १. यत्कृत (ग) (च) for (यकृत)
२. सिद्धं (ग) (च) for (सिद्धांत)
३. ग्रहणादीनां (च) for (ग्रहणार्दानां)
४. विसंवादात् (च) for (विसंवदति)

४३. (घ) १. जातात्येकमपि (च) for (जानात्येकमपि)
२. प्रोक्तानि (ग) for (प्रोक्तोनि)
३. पृथग्दूषणान्येषाम् (ग) पृथग्दूषणान्येषाम् for (पृथक्दुषणात्येषाम्)
(ग) ४. तार्य for (नार्य)
५. काकाल for (काल)
(च) ३. पृथग्दूषणान्येषां for (पृथक्दुषणात्येषाम्)

४४. (घ) १. दूषणानां (ग) पूषणानां for (दुषणानां)
२. मुद्दे शो (ग) (च) for (मुद्दे श्यो)
(च) १. दूषणानां for (दुषणानां)

४५. (घ) १. दूष्येद्यथ (ग) दूष्येप्यथ for (दूष्येष्वथ)
२. स्यात् (च) for (स्थात्)
(ग) ३. कालानांतरेण for (कालांतरेण)
४. दूबकेषु for (दूषकेषु)
(च) १. दूष्येष्वथ for (दृष्येष्वथ)

४६. (ग) १. सिद्धमत्कृत्वम् for (सिद्धमकृत्वम्)
(च) १. मकृत्वं for (मकृत्वम्)

युक्तयार्यभटोक्तानि प्रत्येकं दु[1]षणानि योज्यानि ।
श्रीषेण प्रभृतीनां कानिचि[2]दन्यानि वक्ष्यामि ॥ ४७ ॥
लाटात्[3]सूर्यशशांकौ मध्याविदु[1]च्च चंद्रपातौ च ।
कुजबुधशीघ्रबृहस्पतिसितशीघ्रशनैश्चरान्मध्या[2] ॥ ४८ ॥
युग[1]यातवर्षभगणान् वाशि[4]ष्टान् विजयनंदिकृत[2]पादान्[5] ।
मंदोच्चपरिधि[3]पातस्पष्टीकरणाद्यमार्यभटात् ॥ ४९ ॥
श्री[1]षेण ग्रहित्वा चन्द्र[4]रत्नोच्चयरोमकः कृतः[5] ।
कथा[2] एतान्येव गृ[5]हीत्वा वसि[3]ष्टो विष्णुचन्द्रेण ॥ ५० ॥
अनयोर्न कदाचिदपि ग्रहणादिषु भवति दृष्टिगणितैक्यम् ।
यद् भवति तद्यु[1]गुणाक्षरमतो स्फुटाभ्यां किमेताभ्याम् ॥ ५१ ॥

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४७. (घ) १. दूषणानि (ग) (च) for (दुषणानि)
२. कानिचदन्यानि for (कानिचिदन्यानि)

४८. (घ) १. बिंदूच्च (ग) (च) for (विन्दुच्च)
२. मध्यात् (ग) for (मध्या)
(च) ३. लाटा for (लाटात्)

४९. (घ) १. यान for (यात) २. कृत (ग) कृतम् for (कृत)
३. मंदोच्चपरिपात (ग) मंदोच्चपरिधिपातः for (मंदोच्चपरिधिपात)
(ग) ४. वाशिष्टाद्विजयनंदि for (वाशिष्टान् विजयनंदि)
५. पादम् for (पादान्)
(च) १. युगपात for (युगयात)

५०. (घ) १. श्रीषोणन गृहीत्वा (ग) श्रीषेणगृहीत्वा for (श्रीषेण ग्रहित्वा)
२. कंथा (पहली पंक्ति के अन्त में) for (कथा)
३. वासिष्टो (ग) (च) for (वसिष्टो)
(ग) ४. 'चन्द्र' यहां अंकित नहीं ५. ग्रहीत्वा for (गृहीत्वा)
(च) १. श्रीषेणेन गृहीत्वा for (श्रीषेण ग्रहित्वा)
५. क्रतः for (कृतः)

५१. (घ) १. तद्घुणाक्षर (ग) तत् ग्रुगणाक्षर for (तद्युगुणाक्षर)
(च) १. तद्युगणाक्षर for (तद्युगुणाक्षर)

नाचोच्चवृत्तमध्यस्य गोलबाहुचेन नामकृतमुच्चम् ।
तस्थो न भवत्युच्चो यतस्ततो वेत्ति नोच्चमपि ॥ ५२ ॥
अन्या विक्षेपकला मंदान्यत्वात्फलाधिकाः स्पष्टाः ।
यस्मान्माहायुगादौ न राहुमंदाः स्फुटात्तस्मात् ॥ ५३ ॥
परमालाब्दमिथुनांते द्यु रात्रि नाड्योर्कगतिवशाद्दतवः ।
नायनयुगमयनवशात् स्थिरमयी तद्वितयमपि तस्मात् ॥ ५४ ॥
तद्यु गवधो महायुगमुक्तं श्रीषेणविष्णुचन्द्राद्यैः ।
तत्स्थुलं दृग्लिप्ता माहायुगादौ ग्रहेषु यतः ॥ ५५ ॥
कदिनादौ स्मृतियुक्तं ग्रहभोत्पतिर्दिनक्षये प्रलयः ।
तान्यपि बहुनि यस्मान्महायुगेऽतो प्रसिद्धमिदम् ॥ ५६ ॥

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५२. (घ) १. नीचोच्च (ग) नीचोच्चावृत्त for (नाचोच्चवृत्त)
२. तास्था for (तस्थो)
(च) १. नीचोच्च for (नाचोच्च)

५३. (घ) १. फलाधिका (च) for (फलाधिकाः)
२. महा (ग) (च) for (माहा)
३. स्फुटाः तस्मात् (ग) स्फुटास्तस्मात् for (स्फुटात्तस्मात्)
(च) ३. स्फुटाः तस्मात् for (स्फुटात्तस्मात्)

५४. (घ) १. परमाल्पा (ग) परिमाल्पा for (परमालाब्द)
२. स्थिरमय (ग) for (स्थिरमयी)
(ग) ३. न द्वितयमपि for (तद्वितयमपि)
(च) १. परमाल्पाब्द for (परमालाब्द) २. स्थिरमपि for (स्थिरमयी)

५५. (घ) १. स्थूलं (ग) for (स्थुलं) २. महा for (माहा)
(ग) ३. मयाहायुग for (महायुग)
(च) ३. तत्स्थूलं for (तत्स्थुलं) २. महायुगादौ for (माहायुगादौ)

५६. (घ) १. स्मृतिषुक्तं (ग) स्मृतिषूक्तं for (स्मृतियुक्तं)
२. बहूनि (ग) for (बहुनि)
(ग) ३. पत्तिर्दिनेक्षये for (पतिर्दिनक्षये) ४. युगेतो for (युगेऽतो)
(च) १. स्मृतिषुक्तं for (स्मृतियुक्तं)
३. ग्रहभोत्पत्तिर्दिनक्षये for (ग्रहभोत्पतिर्दिनक्षये)

प्रतिदिवस विसंवादात्[1] ग्रहतिथिकरणर्क्ष दिवसमानानाम् ।
ग्रहणग्रहयोगादिषु पादं पादेन कः स्पृशति ॥ ५७ ॥
अंगचितिविजयनंदिप्रद्यु[1]म्नादीनि पादकरणानि ।
यस्मात्तस्मात्तेषां[2] दूषणान्यत्र लिखितानि ॥ ५८ ॥
इत्ति बहुधा विवदंति ग्रहर्थिनः[1] सद्ग्रहा[2] इव प्रसभम् ।
ब्राह्मे स्फुटसिद्धान्ते रवींदु भूयोगमज्ञात्वा[3] ॥ ५९ ॥
तंत्रभ्रंशं प्रतिदिनमेवं विज्ञाय[1] धिमता[2] यत्नः[3] ।
कार्यस्तस्मै[4] दृग्गणितैक्यं[5] सदा भवति ॥ ६० ॥
चन्द्ररविग्रहणेंदु छायादिषु सर्वदा यतो ब्राह्मे ।
दृग्गणितैक्यंभवति स्फुटसिद्धान्तस्ततो ब्राह्मः ॥ ६१ ॥
योयज्जनात्तेषां[1] स वेत्ति तद्दुषणानि[2] कथितानि ।
आर्यभटाद्युक्तानां तन्त्राणां दुषणाध्याये[3] ॥ ६२ ॥

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५७. (घ) १. विसंवादाद्ग्रह for (विसंवादात्ग्रह) (च) विसंवादाद्ग्रह for (विसंवादात्ग्रह)

५८. (घ) १. अंकचिति (ग) अंकयिति for (अंगचिति)
(ग) २. 'न' यहां अतिरिक्त है ।
(च) १. अंकचिति for (अंगचिति) २. +न+

५९. (घ) १. ग्रहार्चिनः (ग) ग्रहार्थिनः for (ग्रहर्थिनः)
(ग) २. सग्रहा for (सद्ग्रहा) ३. मत्कृत्वा for (मज्ञात्वा)

६०. (घ) १. विज्ञाया (च) for (विज्ञाय) २. धीमता (ग) (च) for (धिमता)
३. यत्ना (ग) यत्तः for (यत्नः) ४. तस्मि (ग) तस्मिन्यस्मिन् for (तस्मै)
५. दृग्गणितै किं for (दृग्गणितैक्य)
(च) ४. कार्यस्तस्मि for (कार्यस्तस्मै)

६२. (घ) १. यं जानात्तेषां (ग) यं जानात्येषां for (यज्जनात्तेषां)
२. दूषणानि (ग) for (दुषणानि)
३. दूषणाध्याये ग) (च) for (दुषणाध्याये)
(च) १. यो यजनात्तेषां for (यो यज्जनातेषां)
२. तद्दूषणानि for (तदुषणानि)

इत्ति[४] कथिततन्त्राणाकान्[१]पठतिरपि[२] दूषणैः करोत्यज्ञानात्[५] ।
तन्त्र परीक्षार्यणां[३] त्रिषष्टिरेकादशोध्यायः ॥ ६३ ॥
इति[६] श्री ब्रह्मगुप्तसिद्धान्ते एकादशोऽध्यायः ।

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६३. (घ) १, २. तन्त्रगणकान्यदितै (ग) तन्त्रगणकान् पठितैरपि for (तन्त्राणाकान्पठतिरपि)

३. परीक्षार्याणाम् (ग) for (परीक्षार्यणां)

(ग) ४. इति for (इत्ति) ५. करोत्यज्ञान् for (करोत्यज्ञानात्)
समाप्तिसूचक चिह्न छः छः छः

(च) १. तन्त्रगणकान्यदितैरपि for (तन्त्राणाकान्यठतिरपि)
५. करोत्यज्ञान् for (करोत्यज्ञानात्)
२. परिक्षार्याणां for (परीक्षार्यणां) ६. 'इति' से 'अध्यायः' तक सब लुप्त ।

अथ गणिताध्यायः

द्वादशः

परिकर्म[६] विंशति[१] यः संक(व)लिताद्यं[२] पृथक्[३] विजानाति ।
अष्टौ च व्यवहारान्[४] छायातान्[५] भवति गणकः सः ॥ १ ॥
विपरीत छेदगुणाः[२] राश्योः[३] छेदांशकाः समछेदाः ।
संकलितेशा[१] योज्या व्यवकलितेंशांतरं कार्यम् ॥ २ ॥
रूपाणि छेदगुणान्यंशयुतानि द्वयोर्बहुनां[१] वा ।
प्रत्युत्पन्नो[३] भवति छेदवधेनोधृतांशवधः[२] ॥ ३ ॥
प्रत्युत्पन्नः परिवर्त्य[५] भागहारछेदांशौ[७] छेदसंगुणछेदः[१] ।
अंशांशगुणो भाज्यस्य[२] भागहारः[६] सवर्णितयोः[३] मागहारः[४] ॥ ४ ॥

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१. (घ) १. विंशंति (ग) for (विंशति) २. संकलिताद्यां (ग) (च) for (संकलिताद्यं)
३. पृथग्विजानाति (ग) (च) for (पृथक् विजानाति)
४. व्यवहां (ग) व्यवहारांस् for (व्यवहारान्)
५. छायांतान् (ग) (च) for (छायातान्)
(ग) ६. परिकर्म्म for (परिकर्म)

२. (घ) १. संकलितेंऽशा (ग) (च) संकलितेंशा for (संकलितेशा)
(ग) २. गुणा for (गुणाः) ३. राश्योश्छेदांशकाः for (राश्योः छेदांशकाः)

३. (घ) १. बहूनां (ग) for (बंहुनां)
२. वधेनोद्धृतांशवधः (ग) बधेनोद्धृतोंशवघः for (वधेनोघृतांशवधः)
(च) १. बंहूनां for (बंहुनां) ३. प्रत्युत्पत्पन्नो for (प्रत्युत्पन्नो)
२. वधेनोद्धृतांशवधः for (वधेनोधृतांशवधः)

४. (घ) १. शंगुण for (संगुण) २. भाद्यस्य (च) for (भाज्यस्य)
३. सवर्णिवयोः (ग) सवर्णितयोः for (सवर्णितयोः)
वि० यहाँ श्लोक समाप्त ।
४. भागहारः (च) for (मागहारः)
(ग) ५. परिवृत्य (इसी पद से श्लोकारंभ होता है)
६. भाहारः for (भागहारः)
वि०-इस श्लोक में "प्रत्युत्पन्नः"..... और "भागहारः" पद अंकित नहीं है।
(च) ७. छेदंशौ for (छेदांशौ)

सवर्णितांशवर्गछेदकृति विभाजितो भवति वर्गः[2] ।
सवर्णितांशमूलं छेदपदेनोधृते[1] मूलम् ॥ ५ ॥
[1]वर्गमूलो [2]स्थाप्योत्पद्यनो[3]न्यकृतिस्त्रिगुणोत्तरसं[8]गुणा च यत्प्रथमा[4] ।
नोत्तरकृतिं[5] [6]रंत्यगुणा [6]त्रिगुणा चोत्तर घनश्च घनः ॥ ६ ॥ घनः समाप्तः[7]
छेदोघना[4] द्वितीयात्[1] घनमूलकृतिस्त्रिसंगुणा[2] सकृतिः ।
शोध्या त्रिपूर्वगुणिता प्रथमात् घनतो[5] घनो मूलं ॥ ७ ॥ घनमूलं समाप्तः[3]
[6]घनमूलं समाप्तः

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५. (घ) १. पदेनोद्धृतं (ग) (च) for (पदेनोधृते)
(ग) २. वर्ग्रः for (वर्गः)

६. (घ) १. वर्ग्र ('वर्ग्रमूलो' यह शब्द पांचवें श्लोक का अंतिम पद है)
२. स्थाप्योंत्यघनो (ग) स्थाप्योंत्यघनोत्यकृति for (स्थाप्योंत्पद्यनो)
३. न्यत्कृति for (न्यकृति) ४. तत् (ग) तत्प्रथमान् for (यत्प्रथमा)
५. उत्तरकृति (ग) उत्तरकृतिरंत्यगुणा for (उत्तरकृतिं)
६. त्रिणा (ग) त्रिगुणाच्चोत्तर for (त्रिगुणा)
७. समाप्तः for (घनः समाप्तः)
(ग) १. यह पद यहाँ लुप्त है । ८. संगुणो for (संगुणा)
(च) २. स्थाप्योंत्यघनोन्यकृति for (स्थाप्योंत्पद्यनोन्यकृति)
५. उत्तरकृतिं for (नोत्तरकृतिं) ६. रत्यगुणा for (रंत्यगुणा)
७. समाप्तः for (घनः समाप्तः)

७. (घ) १. द्वितीयाद्धनमूल (ग) द्द्वितीयाद्धनमूल for (द्वितीयात् घनमूल)
२. संगुणाप्तकृतिः (ग) for (संगुणासकृतिः)
३. समाप्तम् for (समाप्तः)
(ग) ४. छेदाघना for (छेदोघना)
५. प्रथमाद्धनोमूलं for (प्रथमात् घनतो घनमूलं)
वि०-'घनमूलं······समाप्तः'' शब्द अंकित नहीं है ।
(च) १. द्वितियाद्वयनमूलकृति for (द्वितीयात् घनमूलकृति)
२. संगुणाप्तकृतिः for (संगुणा सकृतिः)
५. प्रथमाद्धनतो for (प्रथमात् घनतो)
३. घनमूलं समाप्तं for (घनमूलं समाप्तः)
६. 'घन' से 'समाप्तः' तक लुप्त

सदृश[2]छेदांशयुति[3]छेदविभक्ताफलं प्रथमजातौ ।
अंशै[1]रेशागुणिता छेदै[4] छेदा द्वितीयाभ्याम् ।।८।। प्रथमद्वितीयजाति समाप्त:[5]
ऊर्द्धांशा[3] छेदगुणास्तृतीयजातौ द्वयोः पृथक् परयोः ।
छेदै[4] छेदा गुणिताः स्वांशयुतो[5]नै[1]रूपरिमांशाः ।। ९ ।।
तृतीय चतुर्थीजाति स०[2] ।

त्रैराशिके प्रमाणफलमिच्छाद्यं तयोः सदृशराशिः[1] ।
इच्छाफलेन गुणिता प्रमाण[2]भक्ताफलंभवति ।। १० ।। त्रैराशिकं स०[3]
व्यस्तत्रैराशिकफला[1]मिच्छाभक्तः प्रमाणफलघातः । व्यस्तत्रैराशिकं स०[3]
त्रैराशिकादिषु फलं विषमेष्वेकादशांतेष[2] ।। ११ ।।

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८. (घ) १. रंशा (ग) for (रेशा)
(ग) २. सद्रिश for (सदृश) ३. युतिश्छेद for (युतिछेद)
४. छेदैश्छेदा for (छेदैछेदा)
५. "प्रथम······समाप्त:" शब्द अंकित नहीं है ।
(च) १. अंशैरंशा for (अंशैरेशा)

९. (घ) १. रुपरिमांशाः (च) for (रूपरिमांशा:) २. समाप्तेः for (स०)
(ग) ३. ऊर्ध्वांशाश्छेद for (उर्द्धांशाछेद) ४. छेदैश्छेदा for (छेदैछेदा)
५. युरेता for (युतो)
वि० "तृतीय···से जाति स०" तक अंकित नहीं है ।
(च) २. जाती समाप्ते for (जाति स०)

१०. (घ) १. राशी (ग) (च) for (राशि:) २. प्रमाणक्ता for (प्रमाणभक्ता)
३. समाप्तम् for (स०)
(ग) "त्रैराशिकं समाप्तं" शब्द अंकित नहीं है ।
(च) समाप्तं for (स०)

११. (घ) १. फलमिच्छा (ग) for (फलामिच्छाभक्त:)
२. दश्यंतेषु for (दशांतेषु) ३. समाप्तम् for (स०)
(ग) ३. 'व्यस्त' से 'स०' तक यहां अंकित नहीं है ।
(च) २. दृश्यंतेषु for (दशांतेषु)

फलं[1] संक्रमणमुभयतो[2] बहुराशिवधे तुल[3]वधहृतो ज्ञेयः ।
सकलेष्वेवं भिन्नेषु[4] भयतच्छेदसंक्रमणं ।। १२ ।।
पंचसप्तनवैकादशराशि[5] समातानि ।
प्राग् मूल्यव्यत्यासो भांड[1]प्रतिभांडिके[2]त्यदुक्तः ।
सम[3]परिकर्मान्यि[4]ष्ठानां व्यवहाराणामभिहितानि ।। १३ ।।
कालगुणितं प्रमाणं फलभक्तं व्येकगुण[1]हतं कालः ।
स्वफलयुतरूपभक्तं मूलफलैक्यं भवति मूलम् ।। १४ ।।
कालप्रमाणघातः परकालहृतो द्विधाद्यमिश्रवधात् ।
अन्यार्द्ध[2]कृतियुतात्पद[3]मन्यार्द्धोन प्रमाणफलम् ।। १५ ।।

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१२. (घ) १. फल for (फलं) २. मुयतो for (मुभयतो)
३. वधेऽल्पवध (ग) वधाऽल्पवधहृतो (कृतो) for (वधेतुलवधहृतो)
४. भन्नेषू (ग) भिन्नेषूभयतश्छेद for (भिन्नेषुभयतछेद)
५. राशिकानि for (राशि) (च)

(ग) ५. 'पंच' से 'समाप्तानि' तक पद यहां अंकित नहीं है ।

(च) १. फल संक्रमण for (फलं संक्रमण)
३. तुल्यवधहृतो for (तुलवधहृतो)

१३. (घ) १. भ्यंडप्रतिभ्यंडिके for (भांडप्रतिभांडिके)
२. इत्युदुक्त (अ) न्यदुक्तसमम् for (त्यदुक्तः)
३. सम्रं (अ) for (सम)
४. परिकर्माण्यष्टानां (ग) परिकर्माण्यष्टनां for (परिकर्मान्यिष्टानां)

(ग) ४. परिकर्माण्यष्टानां for (परिकर्मान्यिष्टानां)

१४. (अ) १. हृतं (च) for (हतं)

१५. (ग) १. मन्यार्द्धोनम् for (मन्यार्द्धोन)

(च) २. कृति for (कृति) ३. पदमन्याः र्द्धोन for (पदमन्यार्द्धोन)

प्रश्नेपयोगहृतया[1] लब्धा[2] प्रश्नेपका[3] गुणा लाभाः ।
ऊनाधिकोत्तरार्द्ध[4]स्तद्युतोनया स्वफलमूनं[5] युतम् ।। १६ ।।

मिश्रक व्यवहार[6] समाप्तः

पदमेकहीनमुत्तरगुणितं संयुक्तमादिनांत्यधनम् ।
आदि युतान्त्यधनार्द्धमध्यधनं पदगणं[1] गुणितम्[2] ।। १७ ।।
उत्तरहीना[1]द्विगुणादिशेशवर्गं[2] धनोत्तराष्टवधे ।
प्रश्निप्य[3] पदं शेषोनं द्विगुणोत्तर[5] हृतं[4] गच्छः ।। १८ ।।
एकोत्तरमेकाद्यं[4] यदीष्ट[1]गच्छस्य[2] भवति संकलितम् ।
तद् वियुत्[5] गच्छ गुणितं त्रृहृतं[3] संकलितम्[6] ।। १९ ।।

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१६. (घ) १. प्रक्षेपयोगहृतया (ग) (च) for (प्रश्नेपयोगहृतया)
२. लब्ध्वा for (लब्धा) ३. प्रक्षेपका (ग) प्रक्षेपक for (प्रश्नेपका)
४. त्तरास्तद्युतो (ग) (च) for (त्तरार्द्धस्तद्युतो)
५. मूनयुतम् (ग) (च) for (मूनंयुतम्)
(ग) 'मिश्रक' से 'समाप्तः' तक अंकित नहीं है ।
(च) २. प्रक्षेपका for (प्रश्नेपका)
६. व्यवहारः for (व्यवहार)

१७. (ग) १. पदगुणं for (पदगणं) २. गणितम् for (गुणितम्)

१८. (घ) १. उत्तरहीन (ग) (च) for (उत्तरहीना)
२. शेषवर्ग (ग) (च) शेषवर्ग for (शेशवर्गं)
३. प्रक्षिप्य (ग) (च) for (प्रश्निप्य)
४. हृतं (ग) यह पद अंकित नहीं है । for (हृतं)
(ग) ५. द्विगुणोत्तरं for (द्विगुणोत्तर)
(च) ४. हृतं for (हृतं)

१९. (घ) १. यदिष्ट (ग) (च) for (यदीष्ट) २. गच्छस्य (ग) (च) for (गच्छस्य)
३. हृतं (ग) त्रिहृतं for (त्रृहृतं)
(ग) ४. एकोत्तमेकाद्यं for (एकोत्तरमेकाद्यं)
५. गच्छ for (गच्छ) ६. संकलितं सकलितम् for (संकलितम्)
(च) ५. वियुतगच्छ for (वियुत्गच्छ) ३. त्रिहृतं for (त्रृहृतं)

द्विगुणपदसैकगुणितं तत्र[1]हृतं भवति वर्ग[5]संकलितम् ।
[2]घूनसंकलितं तक्र[3]तिरेषां समगोलकैश्चितयः ॥ २० ॥
[4]श्रेष्टीव्यवहार समाप्तः ॥

स्थूलफलं त्रिचतुर्भुजबाहुप्रतिबाहुयोगदलघातः ।
भुजयोगार्द्धचतुष्टयभुजो न घातात्पदं [1]सुक्ष्मम् ॥ २१ ॥
भुजकृत्यंतरभू[1]र्हृत्तहीनयुताभू[3]र्द्विभाजिता बाधे ।
स्वाबाधावर्गोनाद्भुजवर्गा[2]त्फलमवलंब ॥ २२ ॥
अविषमचतु[4]स्त्रभुज[1]गतिभुजवधयो[2]र्युते पदं कर्णः ।
कर्णकृतिर्भूमुखयुतिदल व(प)र्गो नापदं [3]लंब ॥ २३ ॥

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२०. (घ) १. तत्रिहृतं (ग) तत् त्रिहृतं for (तत्रृहृतं)
२. घन (ग) घनसंकलित for (घूनसंकलितं)
३. तत्कृति (ग) for (तक्रति) ४. श्रेढी व्यवहारः for (श्रेष्टी व्यवहार)
(ग) ५. संलितम् for (संकलितम्)
४. वि० 'श्रेष्टी' से 'समाप्तः' तक यहाँ अंकित नहीं है ।
(च) १. तत्रृहृतं for (तत्रृहृतं) २. घनसंकलितं for (घूनसंकलितं)
३. तत्क्रति for (तक्रति) ४. श्रेढी for (श्रेष्टी)

२१. (घ) १. सूक्ष्मम् (ग) for (सुक्ष्मम्)
(च) १. शूक्ष्मं for (सुक्ष्मम्)

२२. (घ) १. भूर्हृत (ग) भूर्हृत्हीन for (भूर्हृत)
२. मूलमवलंबः (ग) मूलमवलंब for (फलमवलंब)
(ग) ३. भूर्द्विभाजिता बाधे for (भूर्द्विभाजिताबाधे)
(च) १. भूर्हृत for (भूर्हृत) २. मूलमवलंबः for (फलमवलंब)

२३. (घ) १. भुजगतिभुजगति (ग) भुजप्रतिभुजवधयो for (भुजगतिभुजवधयो)
२. भुजवधयोर्युतेः (ग) युतेः for (भुजवधयोर्युते)
३. लंबः (ग) (च) for (लंब)
(ग) ४. चतुरस्त्र for (चतुस्त्र)
(च) २. युंतेः for (युंते)

कर्णकृतेः कोटिकृतं विशोध्य मूलं भुजो भुजस्य कृतिं ।
प्रोह्य यंदं कोटिबाहु कृतियुतिपदं कर्णः ॥ २४ ॥
कर्णयुतादुर्द्धाधरखण्डे कर्णावलंबयोगे ।
वास्वाबाधे स्वयुतिहृते द्विधा प्रथक्कर्णलंबगुणे ॥ २५ ॥
अविषमपार्श्वभुजगुणकर्णो द्विगुणोवलंबकविभक्तः ।
हृदयं विषमस्यभुजः प्रतिकृतिभुजकृतियोगमूलार्द्धं ॥ २६ ॥
त्रिभुजस्य बधोभुजयोर्द्विगुणितलंबोद्धृतो हृदयरजः ।
नृचतुर्भुजहृदय द्विगुणं वहिवृत विष्कुंभः ॥ २७ ॥

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२४. (घ) १. क्रिति (ग) कृति for (कृतं)
२. प्रोह्य पदं कोटिः (ग) for (प्रोह्ययंदं कोटि)
(ग) ३. विशोध्यं for (विशोध्य)
(च) १. कृति for (कृतं)

२५. (घ) १. वा (इस पंक्ति का अंतिम शब्द 'वा' है) (ग)
२. (दूसरी पंक्ति 'स्वा—' से आरम्भ होती है) (ग)
३. ह्रिते (ग) हृते द्विधा पृथक् for (हृतेद्विघा प्रथक्)
(ग) ४. मूर्ध्वा for (दुर्द्धा)
(च) ४. दूर्द्धाधर for (दुर्द्धाधर) ३. हृते for (हृते)

२६. (घ) १. गुणः (ग) (च) for (गुण)
२. (यहां 'कृति' शब्द मूल पाठ में नहीं है) (ग)
(ग) ३. द्विगुणावलंबक for (द्विगुणोवलंबक)
४. विषमभुजः for (विषमस्यभुजः)
(च) २. 'कृति' लुप्त

२७. (घ) १. हृदयं (ग) (च) for (हृदय)
२. वृित्तं (ग) वृंत्त for (वृत)
३. विष्कंभः for (विष्कुंभः)
(ग) ४. त्रुजयो for (भुजयो) ५. लंबोहृतो for (लंबोद्धृतो)
६. त्रि for (नृ) ७. द्विगुणितं for (द्विगुणं)
(च) २. वृत्तं for (वृत्त)

कर्णास्त्रि[1]तभुजघा[2]तैकामुभयथान्योन्यभाजितं गुणयेत् ।
योगेन [3]भुजप्रतिभुजवधयोः कर्णौ[4]पदे विषमे ॥ २८ ॥
विषम[2]चतुरस्त्र[1]मध्ये विषमत्रिभुजद्वयं प्रकल्प पृथक् ।
कर्णद्वयेन पूर्ववदाबाधे लंबकौ च पृथक् ॥ २९ ॥
विषमभुजांतस्त्रिभु[2]जे प्रकल्प्य कर्णौ[3] भुजो तदा[1]वधे ।
पृथ[4]गूर्द्धा धरखण्डे कर्णयुतौ कर्णयोरधरे ॥ ३० ॥
त्रिभुजभु[4]जौभू[1]र्भुमिस्तलल्लंबो[2] उद्ध मवलंब खण्डम् ।
[3]लंबकयोगार्द्ध मधरोनम् ॥ ३१ ॥

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२८. (घ) १. कर्णासृत (ग) कर्णाश्रित for (कर्णास्त्रित)
२. घातैक्य (ग) घातैः क्य for (घातैका)
(ग) ३. 'ज' अंकित नहीं है ४. कर्णौ for (कर्णो)
(च) १. कर्णासृत for (कर्णास्त्रित) २. घातैक्यमुभयथा for (घातैकामुभयथा)

२९. (घ) १. चतुरस्त्रमध्ये (च) for (चतुरस्त्रमध्ये)
(ग) २. विखम for (विषम)

३०. (घ) १. वाधे (ग) तदा माबाधे for (तदावधे)
(ग) २. ये for (जे)
३. कर्णौ भुजौ । (यहां पहली पंक्ति समाप्त—दूसरी पंक्ति 'तदा' से आरम्भ)
४. चरषंडे for (धरखण्डे)
(च) २. स्त्रिभुजे for (स्त्रिभुजे)
३. कर्णौभुजौ for (कर्णौभुजो) ४. पृथगूर्धाधरखण्डे for (पृथगूर्द्धाधरखण्डे)

३१. (घ) वि०—यहां इस श्लोक का उत्तरार्ध लिखना लिपि कार भूल गया प्रतीत होता है, '३१' का संख्याक्रम भी नहीं मिलता ।
१. भूमि for (भुमि) २. लंबयोरधरे (ग) लंबकाधरं for (उर्द्धमवलंव)
(ग) १. भूमि for (भुमि) ३. दूसरी पंक्ति – ऊर्ध्वमवलंबखंडं लंबकयोगार्द्धमधरोनम्
(च) १. भूमिस् for (भुंमिस्)
वि०—यह श्लोक यहां ३१ व ३२ मिला जुला इस प्रकार है—
त्रिभुजभुजौ भूर्भूमिस्तल्लंबोऊर्द्ध मवलम्बखंडं लंबकयोगार्द्धमधरोनं ॥ ३१ ॥
वि० रेखांकित पद से आगे का समस्तभाग ऊपर अन्यहस्त से लिखा हुआ है ।
(ङ) ४. त्रिभुजे for (त्रिभुज) १. तुभूमि for (भूर्भूमि)
२. लम्बकाधरं for (उर्द्धमवलंब) ३. + ऊर्ध्वमवलम्बखण्डम् +

कर्णावलकयुतौ[२] खंडे कर्णावलंबयोरधरे ।
अनुपातेन[३] तुद्गूने[४] उद्धं[५] शून्यांस[१] पाटायाम्[६] ॥ ३२[७] ॥
कृतियुर[१]सदृशराश्योर्बाहुधातो[५] द्विसंगुणो लंबः ।
कृत्यन्तर[२]मसद्दशयो[३]र्द्विगुणं[६] द्विसमत्रिभुजम्दमिः[४] ॥ ३३ ॥
इष्टद्वयेन[१] भक्तो द्विधेष्टवर्ग[२]फलेष्टयोगार्द्धे ।
विषमत्रिभुजस्य[३] भुजा विष्टोनफलार्द्धयोगा[४] भूः ॥ ३४ ॥
इष्टस्य भुजस्य कृति[१]र्भक्तो नेष्टेन तद्वलं[२] कोटिः ।
आयन[३]चतुरस्त्रस्य[४] क्षेत्रस्येष्टाधिका कर्णः ॥ ३५ ॥

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३२. (घ) (वि०—पहली पंक्ति लिपिकार लिखना भूल गया प्रतीत होता है)
१. सून्यांस (ग) तव्यांस for (शून्यांस)
(ग) २. कर्णावलंबकयुतौ (च) for (कर्णावलकयुतौ)
३. अमुपातेन for (अनुपातेन) ४. तद्गूने (ङ) for (तुद्गूने)
५. ऊर्द्ध् वेस् for (उद्धं) ६. पारायाम् for (पाटायाम्)
(च) ७. यहां क्रमसंख्या ३१ ही अंकित है ।
(ङ) २. कर्णावलंबकयुतौ for (कर्णावलकयुतौ)
५. ऊर्ध्वे for (उद्धं) १. सूच्यांस for (शून्यांस)

३३. (घ) १. कृतियुतिर (ग) (च) for (कृतियुर)
२. कृत्यंतर (ग) (ङ) for (कृत्यंतर)
३. मसद्दशयो (ग) (च) (ङ) for (मसद्दशयो)
४. त्रिभुज भूमिः for (त्रिभुजम्दमि)
(ग) ५. घातो (च) (ङ) for (धातो)
६. द्विद्विसमत्रिभुजभूमिः for (द्विसमत्रिभुजम्दमिः)
(च) ४. त्रिभुजभूमिः (ङ) for (त्रिभुजम्दमिः)
(ङ) १. कृतियुतिर for (कृतियुर)

३४. (घ) १. ष्टद्वयेन for (इष्टद्वयेन)
(ग) २. वर्ग्रः for (वर्ग) ३. विषत्रिभुजस्य for (विषमत्रिभुजस्य)
(ङ) २. वर्गः for (वर्ग) ४. योगोभूः for (योगाभूः)

३५. (घ) १. कृति (ग) (च) (ङ) for (कृति)
२. तद्दलं (ग) (ङ) for (तद्वलं) ३. आयत (च) (ङ) for (आयन)
४. चतुरस्रस्य (ग) (च) (ङ) for (चतुरस्त्रस्य)

आयतकर्णौ[5] बाहु[1] भुजकृति[6]रिष्टेन भाजितेष्टोना ।
द्विह्लता[2] कोट्यधिका[7]भूर्मूखमूलाना[3]द्विसमचतुरस्त्रे[4] ॥ ३६ ॥
कर्णक्रति[1]स्त्रिसमभूजा[2]स्त्रयश्चतुर्थो विशोध्य कोटिक्रति[3] ।
बाहुक्रते[4]स्त्रिगुणार्या[5] यद्यधिकोभूर्मुखं हीनः ॥ ३७ ॥
जात्यद्वयकोटिभुजाः परकर्णगुणाः[1] भुजाश्चतुर्विषमे ।
अधिकोभूर्मुखमूनो बाहु द्वितयं भुजावन्यौ[2] ॥ ३८ ॥
इष्टगुणकारगुणितो गिर्युच्छ्रायः पुरांतरमनष्टम् ।
द्वियुतं[1] गुणाकर[2]भाजितमुत्पातोन्यस्य समगत्योः[3] ॥ ३९ ॥
व्यासव्यासार्द्धक्रति[1]परिधिफले व्यासहारिके[2] त्रिगुणे ।
तद्वर्गाभ्यां[3] दशभिः संगुणिताभ्यां पदे सुक्ष्मे[4] ॥ ४० ॥

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३६. (घ) १. बाहू (ङ) for (बाहु) २. हृता (ङ) for (ह्लता)
३. मुंखभूना (ग) for (मूंखमूलाना)
४. चतुर (यहां 'चतुर' के पश्चात् 'स्त्रे' और संख्या क्रम लिखना लिपिकार भूल गया है) ।
(ग) ५. आयनकर्णौ for (आयतकर्णौ)
(च) ६. क्रति for (कृति) ३. भूमुंखमूलाना for (भूमूंखमूलाना)
(ङ) ७. कोटचधिका for (कोट्यधिका) ३. भूमुंखमूना for (भूमूंखमूलाना)
३७. (घ) १. कृतिम् (ग) कृति for (क्रति) २. भुजा (ग) (ङ) for (भूजा)
३. कृतिम् (ग) (ङ) (क्रति) ४. कृते (ङ) for (क्रते)
५. गुणायायद्यधिको (ग) (ङ) for (गुणार्यायद्यधिको)
(च) ३. कृति for (क्रति)
(ङ) १. कृतिस् for (क्रतिस्)
३८. (घ) १. कर्णगुणा (ग) हता for (कर्णगुणाः) २. वन्यो for (वन्यौ)
(च) १. गुणा for (गुणाः)
(ङ) १. कर्णगुणा for (कर्णगुणाः)
३९. (घ) १. द्वियुत (ग) (ङ) for (द्वियुतं)
(ग) २. गुणकार (च) (ङ) for (गुणाकर) ३. समगत्यौ for (समगत्योः)
४०. (घ) १. कृती (ग) कृती (ङ) for (कृति)
२. व्यावहारिके (ग) (च) (ङ) for (व्यासहारिके)
३. तद्वर्गाभ्यां (ग) तद्वर्ग्राभ्यां (च) तद्वर्गाभ्यां for (तद्वगभ्यां)
४. सूक्ष्मे (ग) (च) (ङ) for (सुक्ष्मे)

वृत्ते शरोनगुणितात् व्यासाच्चतुराहतात्पदं जीवा ।
ज्यावर्गश्चतुराहतशरभक्तः शरयुतो व्यासः ॥ ४१ ॥
ज्याव्यासकृतिविशेषान्मूलव्यासांतरार्द्धमिषुरल्पः ।
व्यासो ग्रासोनगुणौ ग्रासो नैक्योद्धतौ बाणौ ॥ ४२ ॥
इष्टशरस्य भक्ते ज्यार्द्धं कृन्तिशरफले युतौ व्यासौ ।
शरयोः फलयोरैक्यं ग्रासौ ग्रासघ्नदुनं तत् ॥ ४३ ॥

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४१. (घ) १. शरोत for (शरोन)
२. व्यासाच्चाँतु (ग) द्व्यासा for (व्यासाच्चतु)
३. ज्यावर्गस्य for (ज्यावर्गश्च) ४. तुराहह for (तुराहत)

(ग) ५. गुणिता for (गुणितात्)

(च) ५. गुणिताद्व्यासाच्च (ङ) for (गुणितात् व्यासाच्च)

४२. (घ) १. व्यासौ (ग) (ङ) for (व्यासो)
२. ग्रासोनैक्याघृतौ (ग) ग्रासोतैक्योद्ध ृतौ for (ग्रासोनैक्योद्धतौ)

(ग) ३. विशेषा मूलं for (विशेषान्मूल)

(च) २. ग्रासोनैक्योघृतौ for (ग्रासोनैक्योद्धतौ)

४३. (घ) १. शरद्वयभक्ते (ग) (च) (ङ) for (शरस्यभक्ते)
२. कृतीशर (ग) (ङ) for (कृंतिशर) ३. युते (ग) (च) for (युतौ)
४. ग्रासाद्यदूनं (ग) ह्यदनंतत् for (ग्रासघ्नदुनं)
५. +क्षेत्र व्यवहारः समाप्तः+

(ग) ६. पले for (फले) ७. व्यासो for (व्यासौ)
८. पलयो for (फलयो) ९. ग्रासो (ङ) for (ग्रासौ)

(च) २. कृती for (कृंति) ४. ग्रामाद्यदूनं for (ग्रासघ्नदुनं)

(ङ) ६. युते for (फले) ३. फले for (युतौ)
४. ग्रासोनमैक्यं for (ग्रासघ्नदुनं)

[२]क्षेत्रव्यवक्षेत्रफलं वेधगुणं समखातफल[८]हृतं[३] त्रिभिः शून्या[४] ।
मुख[५]तुल्यतुल्यभुजैक्या[६]नेकाग्रहृतानि समरस्त्रः[७] ॥ ४४ ॥
मुखतुलयुतिः[१] दलगुणितं[२] वेधगुणं व्यासहारिकं[३] गणितम् ।
मुखतलगुणैक्यार्द्धं[४] वेधेन[६] गणितमौच्चम्[५] ॥ ४५ ॥
उद्र[२]गणिताद्विशोध्य व्यवहारफलं[३]त्रिभिर्भजेच्छेशम्[१] ।
लब्धं व्यवहारफले प्रक्षिप्य फलं[४] भवति सूक्ष्मं ॥ ४६ ॥

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४४. (घ) १. +अथ खातः+ २. ('क्षेत्र व्यव'—यहाँ लुप्त है) २. (ग) + क्षेत्रव्यवहारः +
३. हृतं (ग) for (हतं) ४. शून्याः (ग) सूध्याः for (शून्या)
५. मुषतुल (ग) मुखतुल (च) for (मुखतुल्य)
६. न्येका (ग) न्यैकाग्र for (नेकाग्र)
७. समरज्जुः (ग) (ङ) for (समरस्त्रः)
(ग) ८. फलं (च) (ङ) for (फल)
(च) २. क्षेत्रे व्यवहारः समाप्तः, अथ खातः for (क्षेत्रव्यव)
४. शून्याः for (शून्या) ६. न्येकाग्रहृतानि for (नेकाग्रहृतानि)
७. समरस्रः for (समरस्त्रः)
(ङ) २. 'क्षेत्रव्यव' लुप्त ४. सूच्याः for (शून्या)
५. मुखतलतुल्य for (मुखतुल्यतुल्य)
४५. (घ) १. तल (ग) मुखतलयुति (च) for (मुखतुलयुतिः)
२. गणितं (ङ) for (गुणितं)
३. व्यावहारिकं (ग) (च) (ङ) for (व्यासहारिकं)
४. गणितैक्यार्द्ध (ग) मुखवगतैक्यार्द्ध for (गुणैक्यार्द्धं)
५. मौद्रम् (ड्रम्) (ग) मौत्र for (मौच्चम्)
(ग) ६. गुणम् for (गणित)
(च) १. मुखतलयुति for (मुखतुलयुतिः)
४. गणितैक्यार्द्धं (ङ) for (गुणैक्यार्द्धं) ५. मौध्रम् for (मौच्चम्)
(ङ) १. मुखतलयुति for (मुखतुलयुतिः)
६. +स्याद्+५ मौत्रम् for (मौच्चम्)
४६. (घ) १. छेषम् (ग) च्छेषम् for (छेशम्)
(ग) २. औद्र for (उद्र)
(च) २. तुद्र for (उद्र) १. छेषं for (छेशम्)
(ङ) २. औत्र for (उद्र) ३. भजेत् त्रिभिः शेषम् for (त्रिभिर्भजेच्छेशम्)
४. भवति फलं सूक्ष्मम् for (फलंभवतिसूक्ष्मम्)

खात[१] व्यवहारश्चतुर्थः

आकृतिफलमौ[७]व्याहृतम[२]ग्रतलैक्यार्द्धमौ[३]च्यदै[२]र्ध्यगु[४]णम् ।
घनगु[५]णितमिष्टकाघनफलेन हृ[६]तमिष्टकागणितम् ॥ ४७ ॥

[७]चितिव्यवहारः समाप्तः ॥

विस्तारा[७]यामांगुलघातो मार्ग[२]हितो द्विवे[३]दहृतः ।
कि[४]ष्कं गु[५]लघ्निलब्धं तत्प[८]णवतिर्भवति क[६]र्मः ॥ ४८ ॥

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४७. (घ) १. ख्याव्यवहार (ग) श्री खातव्यवहारश्चतुर्थः for (खातव्यवहारश्चतुर्थः)
२. मरैन्य (ग) मौव्य for (मौच्य)
३. दैघ्य for (दैर्घ्य) ४. गुणाः (च) for (गुणम्)
५. गणित (ग) (च) (ङ) for (गुणित) ६. हृत (ग) (च) (ङ) for (हृत)

(ग) ७. चितव्यवहारः for (चितिव्यवहारः)

(च) १. ख्याव्यवहारश्चतुर्थः for (खातव्यवहारश्चतुर्थः)

(ङ) १. "खात—चतुर्थः" लुप्त ७. मौच्च्याहृत for (मौव्याहृत)
२. मौच्च्य for (मौच्य) ७. इति चितिब्यवहारः for (चितिव्यवहारः समाप्तः)

४८. (घ) १. विस्तराया for (विस्तारायां)
२. मागहितो (ग) माग्रहितो for (मार्गहितो)
३. द्विवेहृतः (ग) द्विवेदहृतः (च) (ङ) for (द्विवेदहृतः)
४. किष्कं (ग) (च) for (किष्कं)
५. गुलानि (ग) (च) (ङ) for (गुलघ्नि) ६. कर्म्मः (ग) for (कर्मः)

(ग) ७. विस्तारायामंगुल for (विस्तारायामांगुल)

(च) ७. विस्ताराया for (विस्तारायां) ६. कर्म्म (ङ) for (कर्मः)

(ङ) ७. विस्तारायामाङ्गुल for (विस्तारायामांगुल)
८. षण्णवति for (पणवति)

शाकादिषु[1] शालमल्यां शतद्वयं जीवके[4] शतं विशं शाल:[5] ।
सरलादिषु[2] सर्वविहग्रूसु[3] चतुः षष्टिः ।। ४६ ।।

क्रवच[6] व्ययहार समाप्तः ।

नवम[1] सूकिषु दशमस्थूलेष्वेकादशो[2] भवत्यणुषु ।
परिधेर्वेधपरिधिः[4] षडंशवर्गो[5] हतो[3] गणितम् ।। ५० ।।

द्विचतुः सत्र्यंशगुणोमित्यंतर[1] बाह्यकोणगः ।
परिधिः[2] प्राग्वत्कृत्वा गणितं तद् गणितं स्वगुणकारहृतं[3] ।। ५१ ।।

राशिव्यवहारः[4] समाप्तः ।

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४६. (घ) १. शालाल्पांश for (शाल्मल्यांश)
२. सरलादिषुशतं सर्व (ग) for (सरलादिषुसर्व)
३. विदारूपु (ग) विवहारुषु for (विहग्रूसु)
(ग) ४. बीजकेन for (जीवके)
५. यहां 'विंशं' पर श्लोकार्ध समाप्त करके 'शाल' से दूसरी पंक्ति आरम्भ है।
(ङ) ६. क्रकचव्यवहारः (च) for (क्रवचव्यवहार)
(च) ५. वीशंशालः for (विशंशालः) २. +शतं+
३. विदारुषु for (विहग्रुसु)
(ङ) ५. विंशं for (विशंशालः) २. ३. शतमथाविदारुषु for (सर्वविहग्रुषु)
६. लुप्त ।

५०. (घ) १. नवमं शूकिषु (ग) नदमः सूकिषु for (नवमसूकिषु)
२. दशमः (ग) (ङ) for (दशम) ३. वर्गाहतो (ग) वर्ग्राहतो for (वर्गोहतो)
(ग) ४. परिधेर्वेधः (च) (ङ) for (परिधेर्वेधः)
(च) १. नवमंशूकिषु for (नवमसूकिषु) ३. वर्गाहतो (ङ) for (वर्गोहतो)
(ङ) १. नवमः शूकिषु for (नवमसूकिषु) ५. परिधेः for (परिधिः)

५१. (घ) १. भित्त्यंतर (ग) (च) for (मित्यंतर)
२. परिधिः (यह शब्द पहली पंक्ति का अन्तिम शब्द है) (ङ)
३. हृतम् (ग) (च) (ङ) for (हृतं)
(ङ) १. भित्त्यन्तर् for (मित्यंतर)
४. इति राशिव्यवहारः for (राशिव्यवहारः समाप्तः)

छायांतरसैकहृतं द्युदलं प्रागपरयो द्युगतशेषम् ।
दिनगतं शेषांशहृतं द्युदलं छायांतरव्येकम् ॥ ५२ ॥
दीपतलशंकुतलयोरंतरमिष्टप्रमाणशंकुगुणम् ।
दीपशिखोच्या शंकुं विशोध्य शेषोद्धृतं छाया ॥ ५३ ॥
छायाग्रांतरगुणिता छाया छायांतरेण भक्ता भूः ।
भूः शंकुगुणा छाया विभाजिता दीप शिखौच्यम् ॥ ५४ ॥

छाया व्यवहार समाप्तः

गुणकार खण्डतुल्यो गुण्यौ गोमूत्रिकाकृतो गुणितः ।
सहितः प्रत्युत्पन्नो गुणकारकभेदतुल्यो वा ॥ ५५ ॥

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५२. (घ) १. +अथछाया+ (आरंभिक प्रकरण का नाम)
२. छायानरसैकहृतं (ग) (ङ) for (छायांतरसैकहृतं)
३. र्द्युगतशेषम् (ङ) (ग) र्द्युगशेषम् for (द्युगतशेषम्)
४. दिनगत (ग) (च) (ङ) for (दिनगतं)
५. हृतं (ग) (च) (ङ) for (हृतं)
६. छायानरव्येकम् (ग) छायामराव्येकम् for (छायांतरव्येकम्)
(च) १. +अथछाया+ ७. हृतं for (हृतं)
३. र्द्युगतशेषं for (द्युगतशेषम्)
(ङ) १. छायानरव्येकम् for (छायांतरव्येकम्)
५३. (घ) १. छंकु (ग) च्यं छं कुं for शंकुं २. दोषोद्धृतं for (शेषोद्धृतं)
(ग) ३. दीपशिखौ (च) for (दीपशिखो)
(च) १. व्याछंकुं for (च्याशंकुं)
(ङ) ३. शिखौच्च्याच्छंकुं for (शिखोच्याशंकुं)
५४. (घ) १. दीपक (च) for (दीप)
(ग) २. भक्ता (अतिरिक्त अंकित) ३. छायाव्यवहारः for (छायाव्यवहार)
(ङ) १. दीपशिखयौच्च्यम् for (दीपशिखौच्यम्)
५५ (घ) १. स्वंज for (खण्ड) २. ण्गुण्यो (ग) गणो for (गुण्यौ)
३. कृतो (ग) (ङ) for (कृतो)
४. प्रत्युत्पन्नौ (ग) प्रत्युत्पन्नो for (प्रत्युत्पन्नो)
(ग) ५. गणितः for (गुणितः)
(ङ) २. गुण्यो for (गुण्यौ)

गुण्यो राशिर्गुणकारराशिनेष्ट[1]धिकोनकेन गुणः ।
[3]गुण्येष्टवधो न [2]यतो [4]गुणकेभ्यधिकोनके कार्यः ॥ ५६ ॥
[1]छेदेनेष्ट [2]युतोनेना संभाज्यादनष्ट[4]मिष्टगुणम् ।
प्रकृतिस्थछेद[3]हृतं [5]लब्धायुतहीनकमनष्टम् ॥ ५७ ॥
गुणछेदफलवधो गुणकहृतो[3] गुण्यभाजितो गुणकः ।
छेदो [4]धृतः फलं गुण्यगुणवधः [2]फलहृतः छेदः ॥ ५८ ॥
[1]गुण्यगुणकारयोः [6]छेदलब्धयो [7]द्वयो [2]द्वयोर्नाशः ।
तेषां [3]दृश्यो [4]व्यस्तौ कृत्वा [5]तस्थानयो रिष्टौ ॥ ५९ ॥

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५६. (घ) १. राशिनेष्टा (ग) (च) (ङ) for (राशिनेष्ट)
२. युतो (ग) (च) (ङ) for (यतो)
(ग) ३. गुण्यष्ट for (गुण्येष्ट) ४. गुणिकेभ्य for (गुणकेभ्य)
(च) ३. गुणेष्ट for (गुण्येष्ट)
(ङ) ४. गुणकेऽभ्यधिको for (गुणकेभ्यधिको)

५७. (घ) १. छेदो नष्टयुतो for (छेदेनेष्टयुतो)
२. नेनाप्तं (ग) (च) (ङ) for (नेनाप्तं)
३. हृतं (ग) (च) (ङ) for (हृतं)
(ग) ४. दिनष्ट for (दनष्ट) ५. लब्ध्वायुतकम् for (लब्ध्वायुतं)
(ङ) ५. लब्ध्या for (लब्ध्वा)

५८. (घ) १. गुण्य (ग) (ङ) for (गुण)
२. फलहृतः (ग) फलहृत (च) for (फलहृतः)
(ग) ३. हृतो for (हृतो)
(ङ) ३. गुणकहृतो for (गुणकहृतो) ४. द्धतः for (धृतः)
२. फलहृतश्छेदः for (फलहृतः छेदः)

५९ (घ) १. गुणागुण for (गुण्यगुण)
१. द्वियोर्द्वयोर्नाशः (ग) वा द्वयोर्द्वयोर्नाशः for (द्वयोर्द्वयोर्नाशः)
(ग) ३. दृश्यो (च) for (दृश्यो) ४. व्यस्तो for (व्यस्तौ)
(च) १. विसर्ग लुप्त २. द्वयोर्द्वयोर्नाशः for (द्वयोर्द्वयोर्नाशः)
५. तस्थानयौ for (तस्थानयौ)
(ङ) ६. कारयोश्छेद for (कारयोः छेद) ७. लब्धयोर्यदि द्वयो for (लब्धयोर्द्वयो)
२. द्वयोर्द्वयो for (द्वयो द्वयो) ३. दृश्यौ for (दृश्यो)
८. श्चेष्टौ for (रिष्टौ)

गुण्यं गुणकारं वा गुणये[3] छेदेन भागहरस्य[1] ।
गुण्यगुणकारराश्यो[4] छेदगुणो भागहरश्च[2] ॥ ६० ॥
छेदस्य[1] छेदरूपं कृत्वा न्यदूक्तवत्सर्वम्[5] ।
अपवर्त्यौ[2] तुल्यो[3] न छदगुणौ[4] छेदगुण्यौ[6] वा ॥ ६१ ॥
स्वविकलषष्टयंशगुणं[4] [6] सकलस्त्र्यंशोद्धतो[1] विकलवर्गः[5] ।
प्रश्नेप्यः[2] सकलकृतौ वर्गघातौ[3] द्वित्रितुल्यवधौ ॥ ६२ ॥
राशेखनं[1] द्विगुणं बहुतरगुणमूनकृति[3]युतं[4] वर्गः ।
राशेरिष्टयुतोनाद्वधः कृतिवेष्ट[2]कृतियुक्तः[5] ॥ ६३ ॥

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६०. (घ) १. भागहारस्य (ग) (च) (ङ) for (भागहरस्य)
२. भागहारश्च (ङ) for (भागहरश्च)
(ग) ३. गुणयो for (गुणये)
(च) २. भागहारश्च for (भागहरश्च)
(ङ) ३. गुणयेच्छेदेन for (गुणयेछेदेन) ४. राश्योश्छेद for (राश्योछेद)
६१. (घ) १. अछेदस्य छेदं (ग) for (छेदस्य छेदरूपं)
२. अपवर्त्यौ for (अपवर्त्यौ) ३. तुल्येन (ग) for (तुल्योन)
४. छेदगुणौ (ग) for (छदगुणौ)
(ग) ५. दुक्तवत्सर्वम् (ङ) for (दूक्तवत्सर्वम्) ६. छेदगुण्यो वा for (छेदगुण्यौ वा)
(च) ५. न्यदुक्तवत् for (न्यदूक्तवत्) २. अपवर्त्त्यौ for (अपवर्त्यौ)
४. छेदगुणौ for (छदगुणौ)
(ङ) १. अच्छेदस्य for (छेदस्य)
३, ४, ६. छेदगुणौ तुल्येनेष्टेन for (तुल्यो न छदगुणौ छेद)
६२. (घ) १. सकलस्त्रिंशोद्धृतो (ग) सकलंस्त्रिशोहृतो for (सकलस्त्र्यंशोद्धतो)
२. प्रक्षेप्यः (ग) (च) (ङ) for (प्रश्नेप्यः)
३. वर्गघनौ (ग) वर्ग्रघनौ for (वर्गघातौ)
(ग) ४. वश्यंशगुणः for (षष्टयंशगुणं) ५. वर्ग्रः for (वर्गः)
(च) १. सकलंस्त्रिशो हृतो for (सकलस्त्र्यंशोद्धतो)
(ङ) ६. गुणः for (गुणं) १. सकलांस्त्रिशोद्धतो for (सकलस्त्र्यंशोद्धतो)
३. वर्गघनौ for (वर्गघातौ)
६३. (घ) १. रूनं (ग) (च) (ङ) for (खनं) २. वेंष्ट (ग) (च) for (वेष्ट)
(ग) ३. कृवि for (कृति) ४. बुतं वर्ग्रः for (युतं वर्गः)
५. र्युक्तः for (युक्तः)
(च) ३. क्रति for (कृति) (ङ) २. कृतिर्वेष्ट for (कृतिवेष्ट)

इष्टाल्पराशिवर्गौ युक्तोना वितरत्रिकलवर्गाभ्याम् ।
द्विगुणोत्तरराशिभ्याम् भक्तौ तेनाधिकाभ्याम् ॥ ६४ ॥
स्थानांतरेषु लब्धं येन समं फलयुतोनकछेदः ।
दलितकृतियोगान्तरपदमितरो वा फलयुतो नः ॥ ६५ ॥
दिग्मात्रमेतदन्या ज्योत्पत्तौ कुट्टके च कथयिष्ये ।
संकलितादिष्टार्याः षट्षष्टिर्द्वादशोऽध्यायः ॥ ६६ ॥

इति ब्रह्मगुप्ते द्वादशोऽध्यायः ।

इति श्री ब्राह्मस्फुट सिद्धान्ते द्वादशोध्यायः ।

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६४. (घ) १. द्विगुणोतर (ङ) for (द्विगुणोत्तर)
२. तेनाधिकोनाभ्याम् (ग) (च) (ङ) for (तेनाधिकाभ्याम्)
(ग) ३. भक्तो for (भक्तौ)
(च) १. द्विगुणोतर for (द्विगुणोत्तर)

६५. (घ) १. दलितः (ग) (च) (ङ) for (दलित)
(ग) २. 'समं' यहां अंकित नहीं है ।
(ङ) ३. युतोनकच्छेदः for (युतोनकछेदः)

६६. (घ) १. संकलितादिष्वार्याः (ग) for (संकलितादिष्टार्याः)
२. +६६+
३. यह पंक्ति इस प्रति में लुप्त है । (ग)
(ग) ४. दिग्मात्रामेतदत्य for (दिग्मात्रमेतदन्या)
(च) ३. 'इति' से 'अध्याय' तक समाप्तिसूचक वाक्य लुप्त ।
(ङ) ४. दिङ्मात्रमेतदन्यज् for (दिग्मात्रमेतदन्या)
१. दिष्वार्या for (दिष्टार्याः)

अथ प्रश्नाध्यायः

त्रयोदशः

तत्र तावन्मध्यगत्युत्तराध्यायः

प्रश्नध्यायान्[1] प्रवक्षामि[3] सोत्तरान् गणकबुद्धिवृद्धि[4]करान् ।
यैर्ज्ञातैस्तन्त्रविदामाचार्यो भवति बुद्धिमताम्[2] ॥ १ ॥
अधिमासकैः[2] सविकलैर्दृष्टै र्युगयातमवमररात्रैर्वा[3] ।
द्युगणेन वायुगगतयो[1] वेत्ति स कालतंत्रज्ञः[4] ॥ २ ॥
अवमाति[3] यः[4] सविकलैरधिमासैरधिकमासकानवमैः ।
ग्रहमिष्टं ताभ्यां वायो वेति[1] स कलतंत्रज्ञ[2] ॥ ३ ॥
द्युगुणं[1] विनाधिमासावमैर्विनादिन गणेन चन्द्रार्क्कौ ।
ताभ्यां विना[2]स्फुटतिथिं यो वेत्ति स काल[3]तंत्रज्ञः ॥ ४ ॥
इष्टान्मध्यादन्यांस्तिथि[3]मिष्टान्मध्यमाच्छशिग्रहणम् ।
इष्टाद्रविंदु[1]पातै र्यो[2] वेत्ति बिना[4] स तंत्रज्ञः ॥ ५ ॥

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१. (घ) १. प्रश्नाध्यायान् (ग) प्रस्नाध्यायान for (प्रश्नध्यायान्)
 २. बुद्धिमत्यम् (ग)बुधिमताम् for (बुद्धिमताम्)
 (ग) ३. वक्ष्यामि for (प्रवक्षामि) ४. 'वृद्धि' पद अंकित नहीं है ।
 (च) १. प्रश्नाध्यायान् for (प्रश्नध्यायान्)

२. (घ) १. वायुगगं (ग) वायुगगतं for (वायुगगत)
 (ग) २. अधिमासिकैः for (अधिमासकैः) ३. मवमरात्रैर्वा for (मवमररात्रैर्वा)
 ४. तत्रज्ञः for (तंत्रज्ञः)
 (च) ३. मवमरात्रैर्वा for (मवमररात्रैर्वा)

३. (घ) १. वेत्ति (च) for (वेति)
 २. कालतंत्रज्ञः (ग) सकलतंत्रज्ञः for (सकलतंत्रज्ञ)
 (ग) ३. अवमानि for (अवमाति) ४. 'यः' पद यहाँ अंकित नहीं है ।
 (च) २. सकालतंत्रज्ञः for (सकलतंत्रज्ञ)

४. (घ) १. द्युगणं (ग) (च) for (द्युगुणं)
 (ग) २. 'विना' अंकित नहीं ३. 'सकाल' अंकित नहीं

५. (घ) १. रवींदु (ग) for (रविंदु) २. यो for (र्यो)
 (ग) ३. दन्यास्तिथि for (दन्यांस्तिथि)
 ४. 'बिनास' पद अंकित नहीं । इसके स्थान में यहाँ 'सकल' अंकित है ।
 सकल for ('बिनास)

त्रिगुणः शनिरिन्दुनोन्यभगणलब्धैर्ग्रहादिभिः सहितः ।
भौमोऽर्कोगुरुरिंदुच्चं वान्यभगणाः के ॥ ६ ॥
द्वित्रिगुणयो रविर्द्वोर्युति कुजोनान्यभगणलब्धेन ।
राश्यादिनाधिकगुरूरूना शशिरन्यभगणाः के ॥ ७ ॥
द्रष्टोदयिकानश्विन्यौ दयिकात्वाकरो तिथौ मध्यात् ।
मध्यार्कं गुणार्कं गुणमिष्टं मध्यं स तंत्रज्ञः ॥ ८ ॥
पातोनतुल्योमगतीन् प्रतिलोमगतीन् ।
ग्रहान् दिवसं वारं विपरीतैः शन्याद्यैर्यो वेत्ति स कालतंत्रज्ञः ॥ ९ ॥

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६. (घ) १. रिन्दुनोऽन्य (ग) रिन्दूनोन्य for (रिन्दुनोन्य)
२. ग्रहादिभिः (ग) for (ग्रहादिभिः)
३. भौमो हीनोर्का (ग) भौमो हीनोर्को for (भौमोऽर्को)
४. वाऽन्यभगणाः for (वान्यभगणाः)
(ग) ५. रिंदूच्चं for (रिंदुच्चं)
(च) ३. भौमोर्क्को for (भौमोऽर्को)

७. (घ) १. रवींद्वोर्युतिः (ग) रवींद्वोर्युतिः (च) for (रविर्द्वोर्युति)
२. नाधिका (ग) for (नाधिक) ३. शनि (ग) for (शशि)
(च) ३. शनि for (शशि)

८. (घ) १. इष्टौ (ग) for (द्रष्टो)
२. यो (ग) (च) for (ौ)
(ग) ३. दयिकोनश्विन्यौ for (दयिकानश्विन्यौ)
४. दयिको न वा for (दयिकात्वा)
(च) १. इष्टोदयिका for (द्रष्टोदयिका) ५. मध्यार्क्क for (मध्यार्कं)
६. गुणमिष्टं for (गुणमिष्टं)

९. (घ) १. पातानतु लोमगतीन् (ग) पातानतु लोमगतीन् for (पातोनतुल्योमगतीन्)
२. दिवस (ग) for (दिवसं)
(च) १. पातोनतुलो for (पातोनतुल्यो)
३. वत्ति for (वेत्ति)

व्यतिपातवैधृतबृहस्पतिवर्षस्वोच्चनीचपरिवर्तनात् ।
द्विग्रहयोगांश्च युगे यो वेत्ति स कालतंत्रज्ञः ॥ १० ॥
सावनमासाब्दाधिप होरेशानिष्टमध्यसंयोगात् ।
इष्टगुणितैर्युतोना दिष्टान्यो वेत्ति गणकः सः ॥ ११ ॥
युगरविदिवसैर्गुणिता गताधिमासाः स्वशेषसंयुक्ता ।
भक्ता युगाधिमासैः फलं युगादेर्गता दिवसाः ॥ १२ ॥
गुणितानि चन्द्रदिवसैर्गतावमानि स्वशेषसहितानि ।
विभजेद्युगावमैः फलमनष्टमधिमासकैर्गणितम् ॥ १३ ॥
हृतमिंदुदिनैर्लब्धाधिमासदिवसैर्विहिनकमनष्टम् ।
युगयातदिनान्यधिमासदिनगणेष्टग्रहाद्यमत ॥ १४ ॥
द्यु गुणेंदुदिवसघातात् कुदिनाप्तमधोयुगादिमासगणम् ।
युगशशिदिनभक्तं फलमासदिनोनं युगगतदिनानि ॥ १५ ॥

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१०. (घ) १. परिवर्त्तात् (ग) परिवर्त्तान् for (परिवर्तनात्)
२. योगांश्च (च) for (योगाश्च)
(ग) ३. व्यतीपात for (व्यतिपात) ४. सकलतंत्रज्ञः for (सकालतंत्रज्ञः)
(च) १. परिवर्त्तान् for (परिवर्तनात्)
११. (ग) १. गुणिति for (गुणितै)
१२. (घ) १. गुणिताधिमासाः for (गुणितागताधिमासाः)
२. संयुक्ताः (ग) (च) for (संयुक्ता)
(च) १. गुणिता for (गुणिता)
१३. (घ) १. मानिः for (मानि)
२. र्गुणिता (ग) गुणितम् for (र्गणितम्)
(च) २. र्गुणितं for (र्गणितम्)
१४. (घ) १. हृत (ग) (च) for (हृत) २. लब्धा for (र्लब्धा)
३. विहीन (च) for (विहिन) ४. दिनाऽन्यधि for (दिनान्यधि)
(ग) ५. मिंदू for (मिंदु) ६. ग्रहाद्यमतः for (ग्रहाद्यमत)
१५. (घ) १. गणेंदु (ग) (च) for (गुणेन्दु)
(ग) २. कुदिनाप्तं for (कुदिनाप्त) ३. मधोर्यु for (मधोयु)
४. गुणम् for (गणम्)
(च) ४. युगाधिमासगणं for (युगादिमासगणम्)

गुणमधिमासकशेषं युगकुदिनैः खमशेषमधिमासैः ।
तद्युतिरिंदुदिनहृताधिमासशेषं स्फुटं भवति ॥ १६ ॥
कुदिनगताधिकमासकघातः स्पष्टाधिमासशेषयुतः
भक्तो युगाधिमासैरहार्गणः पूर्ववन्मध्याः ॥ १७ ॥
भूदिनगता इवमवधः शेषयुक्तो युगावमविभक्तः ।
लब्धं भवति द्युगुणो युगयातो मध्यमाः प्राग्वत् ॥ १८ ॥
युगगतराशिमासवधाद्रविमासाप्तं दिनाकृतिं सदिनम् ।
भूदिनगुणशशिदिनहृतपाप्तमहर्गणः मैकम् ॥ १९ ॥

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१६. (घ) १. दित for (दिन) २. हृताधि (च) for (हृताधिमास)
(ग) ३. शेषस्फुटं for (शेषं स्फुटं)

१७. (ग) १. 'क' अंकित नहीं
२. मासरहर्ग्रणः for (मासैरहार्गणः)
३. पूर्ववत् मध्या for (पूर्ववन्मध्या)
(च) २. युगाधिमासैरहर्गणः for (युगाधिमासैः रहार्गणः)

१८. (ग) १. वधः स्वशेष for (वधः शेष)
२. द्युगणो (ग) (च) for (द्युगुणो)
(ग) ३. मध्यमा for (मध्यमाः)
(च) १. +स्व+

१९. (घ) १. युगगराराशि (ग) ध्रुगतराशि for (युगगतराशि)
२. दिनीकृतं (ग) (च) for (दिनाकृतं)
३. गुणं for (गुण)
४. शशिदिनैर्हृता (ग) शशिदिनहृत for (शशिदिनहृत)
५. मातमहर्गणः (ग) मातमहर्ग्रणः for (पाप्तमहर्गणः)
६. सैकम् (ग) (च) for (मैकम्)
(ग) ७. मासास्त for (मासाप्तं)
(च) ५. मातमहर्गणाः for (पाप्तमहर्गणः)
४. दिनहृत for (दिनहृत)

गतदिवसा[५] पृथक् विमासक[१] गुणिता रविदिनाप्तमासदिनैः[७] सहिता[२] ।
पृथग्वमगुणा[३] शशिदिवसाप्तोन[६]काकपणाः[४] ॥ २० ॥

गुणिताद्युगाधिमासैर्युगभू[२] दिवसैर्हृ[३]तादवमशेषात् ।
फलयुक्तमधिकमासकशेषं मध्यावतोऽर्केंदू[१] ॥ २१ ॥
अधिमासो[३]वमशेष[१]युगशशिभूहृते[२] पृथग्लब्धे
मासदिनाद्यैस्त्याज्ये गतमासदिनानि चैत्राद्यैः[४] ॥ २२ ॥
अवमावशेषलब्धा[२] सहितानि[३] पृथक् त्रयोदश[४]गुणानि[५] ।
अधिमास शेषलब्धा हीनानि[१] पृथग् रविशशांकौ[६] ॥ २३ ॥

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२०. (घ) १. पृथगविमासकगुणिता (ग) पृथगधिमासकगुणिता for (पृथक् विमासक-गुणिता)
२. सहिताः (ग) for (सहिता)
वि० यह दूसरी पंक्ति का आरंभिक शब्द है
३. पृथगवमगुणाः (ग) for (पृथग्वमगुणा)
४. द्युपणाः for (कपणाः)
(ग) ५. गतदिवसाः for (गतदिवसा)
६. दिनसाप्तोन······॥ २० ॥ for (दिवसाप्तोन)
(च) १. पृथगविमासक for (पृथक् विमासक)
७. मासदिनैसहिताः for (मासदिनैः सहिता)
३. पृथग् वमगुणाः for (पृथग्वमगुणा) ४. काद्युपणाः for (काकपणाः)
२१. (घ) १. ऽर्केन्दुः for (ऽर्केंदू)
(ग) २. (भू) अंकित नहीं ३. हृंता for (र्हृता)
४. फलयुक्तं मधिमासशेषं for (फलयुक्तमधिकमासकशेषं)
(च) ३. हृता for (हृंता) १. मध्यावतोऽर्क्कंदू for (मध्यावतोऽर्केंदू)
२२. (घ) १. शेषे (ग) for (शेष)
२. भूदिनहृते (ग) भूदिनहृता for (भूहृते)
(ग) ३. मधिमासावम for (अधिमासोवम)
४. चैत्रदैः for (चैत्राद्यैः)
(च) २. +दि+
२३. (घ) १. हीनातिपृथग् for (हीनानि पृथग्)
(ग) २. लब्धाः for (लब्धा) ३. सहिता for (सहितानि)
४. तयोर्दश for (त्रयोदश) ५. गुणाणेनि for (गुणानि)
६. शशिकौ for (शशांकौ)

गतमासदिनावशेष[2]लब्धियोगाः[3] त्र्योदश[4]गुणाच्च ।
अधिमासशेषलब्धारविचन्द्रोच्चै[1] युते शोध्ये ।। २४ ।।
केन्द्रे[3] पृथक्[4] फले द्वादशोद्धृते न्यस्तमृण[5]धनं सौरम् ।
अनुलोममैंदवं[1] मासदिनावमशेषलब्धियुतौ[2] ।। २५ ।।
तिथिविकलषष्टि[1]घाताद्रविहृत[2]भुक्त्यंतराप्त[3]घटिकासु[4] ।
देशांतरमनुलोमं[5] भुजांतरं[6] चार्कं[7] फलमसवः ।। २६ ।।
अवमविकलं न सावनमेभिः परिकल्पितं यतश्चांद्रम्[2] ।
नार्यभटाद्यैः प्रश्नो[3] मध्यान्यत्वा कृतो[1] ज्ञातः ।। २७ ।।
ज्ञातभुगणादि[1]भुक्तं सविकलमिष्ट युगभगणसंगुणितम्[3] ।
ज्ञातयुगभगणभक्तं मध्योभगणादिफलमिष्टः[2] ।। २८ ।।

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२४. (घ) १. चन्द्रोच्चे for (चन्द्रोच्चै)
(ग) २. दिनावमशेष for (दिनावशेष)
३. योगा for (योगाः) ४. त्र्योदश for (त्र्योदश)
(च) ४. त्रयोदश for (त्र्योदश)

२५. (घ) १. मैंदवं (ग) मैवं for (मैंदवं)
२. लब्धयुतौ for (लब्धियुतौ)
(ग) ३. केन्द्रं for (केन्द्रे) ४. प्रथक् for (पृथक्)
५. बस्तमृण for (न्यस्तमृण)

२६. (ग) १. 'ष्टि' for (षष्टि)
२. द्रविहित for (द्रविहृत) ३. भुक्तांतराप्त for (भुक्त्यंतराप्त)
४. घटीकासु for (घटिकासु) ५. मनुलोमौ for (मनुलोमं)
६. भुजांतर for (भुजांतरं) ७. वाऽर्क for (चार्कं)
(च) २. द्रविहृत for (द्रविहृत)
७. चार्क्क for (चार्कं)

२७. (घ) १. त्कृतोऽज्ञातः for (कृतोज्ञातः)
(ग) २. यतश्चान्द्र for (यतश्चान्द्रम्) ३. प्रस्नो for (प्रश्नो)

२८. (घ) १. भगणादि (ग) (च) for (भुगणादि) २. मिष्टम् for (मिष्ट)
(वि०)—इस श्लोक की दोनों पंक्तियों के मध्य में निम्नांकित तीसरी पंक्ति भी दी गई है—
"ज्ञात युगभगणादिभुक्तं सविकलमिष्ट युग भगण संगुणितम्"
(ग) ३. संयुगुणितम् for (संगुणितम्)

इष्टाहृतभक्तानां ध्व्यादिनां संयुतेर्द्वयोरथवा ।
इष्टगुणकारगुणयोर्विभक्तयोर्वांतरादथवा ॥ २९ ॥
ज्ञानैकभगण भुक्तिस्तद्भगमाप्त यदिष्टभगणेभ्यः ।
भगण दिवसविकलं सविकलेष्टभगणादि गुणमिष्ट ॥ ३० ॥
शशिदिनगुणं सविकलं वद्भ्‌ुक्तं मंडलादितद्भगणैः ।
विभेजफलं सविकलास्थितयः प्राग्वत् स्फुटीकरणम् ॥ ३१ ॥
पातेंदुयोगलब्धौ कृत्वा देशांतराद्यमनुलोमम् ।
विक्षेपो स्यात्सूर्यादिभिर्विनेंदुग्रहणमेवम् ॥ ३२ ॥
कुदिनहुतमवशेषं द्वादशभिर्गुणितं मासमशद्यम् ।
द्वादशगुणतिथ्यंशैर्युतं धनं भास्करे चंद्रः ॥ ३३ ॥

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२९. (घ) १. नांद्यादीनां (ग) नां द्व्यादीनां for (ध्व्यादिनां)
(ग) २. वांतरदथवा for (र्वांतरादथवा)
(च) १. द्व्यादीनां for (ध्व्यादिनां)

३०. (घ) १. ज्ञातैक (च) for (ज्ञानैक)
२. भाप्तं (च) for (माप्त)
३. भगणादिसविकलं for (भगणदिवसविकलं)
(ग) ४. भगणस्तद्भगणात्त for (भगणभुक्ति) ५. यं for (य)
६. भगणादि दिसविकलं for (भगणदिवसविकलं)
७. गुणमिष्टम् for (गुणमिष्ट)
(च) ६. भगणा for (भगण)

३१. (घ) १. विभजेत्फलं (च) for (विभेजफलं)
(ग) २. यद्भ्‌ुक्तं for (वद्भ्‌ुक्तं)
३. स्तिथयः (च) for (स्थितयः)

३२. (घ) १. विक्षेपोस्मात् (ग)(च) for (विक्षेपोस्यात्)
(च) २. क्रत्वा for (कृत्वा)

३३. (घ) १. हृत for (हुत) २. माप्त (ग) (च) for (मास)
(ग) ३. मवमशेषं for (मवशेषं) ४. र्गुणित for (र्गुणितं)
५. मंशाद्यम् for (मशद्यम्) (च)
(च) १. हृत for (हुत)

द्यु[1]गुण युगाधिमासैर्गुणितं युगभू[5]दिनैर्भजे[2]ल्लब्धम् ।
भगणादिमध्यमार्क[3]स्त्र्योदश गुणाधिक[4]श्चन्द्रः ॥ ३४ ॥
इष्टगुणकारगु[1]णितं ग्रहभगणै[3]क्यांतर यथा नि[4]हितम् ।
कृ[6]त्वा कुदिनैर्वि[5]भजे छेशो न युतानि कुदिनानि ॥ ३५ ॥
अ[1]घनभगणलब्धं घ[2]नर्णमिष्टग्रहस्य युगभगणैः ।
अन्यफलमृणधनं चेद्रूनयुतान्यन्ययुगभगणाः ॥ ३६ ॥
भदिनानि ग्रहभगणैरूनानि भवंति साव[2]नदिनानि ।
इष्टाश्वि[1]न्योदयिकाः स्वसावनैः पूर्ववन्मध्याः ॥ ३७ ॥
रविभगणाप्तं[1] दिसविकलं ज्ञेयमंडलेभ्यो यत् ।
मध्या[3]र्कसविकलकलासंगुणितं ज्ञेयमध्यम[2]कलाः ॥ ३८ ॥

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३४. (घ) १. द्युगणं (ग) द्युगुणं for (द्युगुण) २. भीजल्लब्धम् for (भंजेल्लब्धम्)
३. मध्यमार्कत्रयोदश (ग) for (मध्यमार्कस्त्र्योदश)
४. गुणाधि चेंदुः (ग) गुणाधिकं चन्द्रः for (गुणाधिकश्चन्द्रः)
(ग) ५. भूदि नै (च) for (भूर्दिनै)
(च) १. द्युगणं for (द्युगुण) ३. मध्यमार्क्कत्रयोदश for (मध्यमार्कस्त्र्योदश)
४. गुणाधिकश्चेंदुः for (गुणाधिकश्चन्द्रः)

३५. (घ) १. गुणित for (गुणितं)
२. छेषोऽनयुतानि for (छेषो न युतानि)
(ग) ३. क्यांतरं for (क्यांतर)
४. भिहितम् for (निहितम्)
५. विभजेत् शेषो for (विभजे छेषो)
(च) ६. क्रत्वा for (कृत्वा)

३६. (घ) १. यद्यन्य (ग) for (अघन) २. धनर्ण (ग) for (घनर्ण)
(च) १. अद्य for (अघ) २. धनर्ण्य for (धनर्ण)

३७. (घ) १. इष्टाश्विन्यौदयिकाः (ग) for (इष्टाश्विन्योदयिकाः)
(ग) २. सवनदिनानि for (सावनदिनानि)

३८. (घ) १. रविभगणाप्तलिप्तादि for (रविभगणाप्तम्)
(ग) २. मध्यकलाः for (मध्यमकलाः)
(च) ३. मध्यार्क्क for (मध्यार्क)

इष्टभगोन[1] भूदिनशेषैर्भगणैः क्रतो मध्यः[2] ।
अनुलोगमगो विलोमो भवति विलोमोनुलोमगतिः[3] ।। ३९ ।।
द्युगुणेन[1] कुदिनशेषैरनुलोमगो[3] विलोमगतिः ।
भवति विलोमो मध्योरनुलोमगो[2] वाक्रतः प्राग्वत्[4] ।। ४० ।।
कल्पदिनसप्तकवधात् कल्पगताहर्गणोनकच्छेषात्[2] ।
सप्तहृता[1] दिनवारः शेषं[3] शन्यादिको भवति ।। ४१ ।।
व्यतिपात[3] वैधृतान्यर्क[5] चंद्रभगणयुताद्विसंगुणिता[4][1] ।
गुरूवर्षाण्याश्वा युजा द्वादशगुणिताः[2] गुरोर्भगणाः ।। ४२ ।।
स्वोच्चग्रहयुगभगणा विशेषिता[2]स्वोच्चनीचपरिवर्ताः ।
भगणांतरं वियोगा[1] कार्यस्त्रैराशिकेन गताः ।। ४३ ।।

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३९. (घ) १. इष्टभगणोन (ग) (च) for (इष्टभगोन)
२. क्रतोग्रहो मध्यः for (क्रतोमध्यः)
३. लोमोऽनुलोमगतिः (ग) तिलोमोनुलोमगतिः for (विलोमोनुलोमगतिः)
(च) २. क्रतो ग्रहोमध्या for (क्रतोमध्यः)

४०. (घ) १. द्युगणोन (ग) (च) for (द्युगुणेन)
२. मध्योऽनुलोमगो (ग) मध्योनुलोमगो for (मध्योरनुलोमगो)
(ग) ३. शेषैर्भगणै for (शेषैरनुलोमगो) ४. प्रग्वत् for (प्राग्वत्)
(च) २. मध्योऽनुलोमगो for (मध्योरनुलोमगो)

४१. (घ) १. सप्तहृताह्निवारः (ग) सप्तहृतादिनवारः for (सप्तहृतादिनवारः)
(ग) २. हृग्र्गणो for (हर्गणो) ३. शेषः for (शेषं)
(च) १. सप्तहृताह्निवारः for (सप्तहृतादिनवारः)

४१. (घ) १. संगुणिताः (ग) (च) for (संगुणिता)
२. गुणिता गुरोर्भगणाः (ग) for (गुणिताः)
(ग) ३. व्यतीपात for (व्यतिपात) ४. भगणा for (भगण)
(च) ५. वैधृतान्यर्क्क for (वैधृतान्यर्क) २. गुणिता for (गुणिताः)

४३. (घ) १. द्वियोगाः (ग) (च) द्वियोगा for (वियोगा)
(ग) २. विशेषिताः for (विशेषिता)

द्युगुणास्त्रिशद् भक्ताद्यलब्धं द्विगुणितं सरूपं तत् ।
सप्तविभक्तं शेषः सावनमासाधिपोर्कादि ॥ ४४ ॥
षष्टिशतत्रयभक्तात् कल्पगताहर्गणात्फलं त्रिगुणम् ।
सैकं सप्तविभक्तं सायनवर्षाधिपोर्कादि ॥ ४५ ॥
अर्कोनलग्नहोरा पंच गुणाः सविकलाः यदि सरूपाः ।
सप्तविभक्ता शेषो दिनाधिपात् कालहोरेशः ॥ ४६ ॥
त्रिचतुरनंतर षष्टयः सावनमासाब्ददिनसहोरेशाः ।
दिनगतघटिका द्विगुणा पंच हृताश्चान्यमतमेतत् ॥ ४७ ॥
गछधनमिष्ट गुणितैधनैर्युतोनं पृथक् पृथक् सहितम् ।
गुणक युतोन पदहृत सर्वधनमतोवशेषाणि ॥ ४८ ॥

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४४. (घ) १. द्युगणास्त्रिशद् (ग) (च) for (द्युगुणास्त्रिशद्)
२. यल्लब्धं (ग) भक्तात् यल्लब्धं for (भक्ताद्यलब्धं)
३. ऽर्कादिः for (र्कादि)
(ग) ४. सरूप for (सरूपं)
(च) २. भक्ताद्यल्लब्धं for (भक्ताद्यलब्धं) ३. क्र्कादिः for (र्कादि)

४५. (घ) १. र्कादिः for (र्कादि)
(ग) २. हर्ग्रणा for (हर्गणा) ३. सैक for (सैकं)
(च) १. क्र्कादिः for (र्कादि)

४६. (घ) १. सप्तविभक्ताः (ग) (च) for (सप्तविभक्ता)
(ग) २. होराः (च) for (होरा) ३. सविकला for (सविकलाः)
४. दिनपाद्यः काल for (दिनाधिपात् काल)
(च) ५. अर्क्कोन for (अर्कोन)

४७ (घ) १. षष्टाः (ग) (च) for (षष्टयः) २. दिवस(ग) for (दिनस)
३. द्विगुणाः (ग) (च) for (द्विगुणा)
(च) २. मासाब्द्दिवसहोरे रेशाः for (मासाब्ददिनसहोरेशाः)

४८ (ग) १. गुणतै for (गुणितै) २. हृतं for (हृत)
(च) ३. शाषेणि for (शेषाणि)

मध्योत्तरमेकोनार्याः पंचाशत्त्रयोदशोध्यायः[1] ।
ज्ञात्वैनं तंत्रविदामाचार्यो भवति मध्यगतौ ।। ४६ ।।

इतित्र्योदशोऽध्यायः[1]

इति ब्राह्मस्फुटसिद्धान्ते मध्यगतिप्रश्नोत्तराध्यायः
त्रयोदशः ।

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४६ (घ) १. पंचाशत्त्रयोदशोध्यायः (ग) पंचशत्त्रयोदशोव्यायः for (पंचाशस्त्रयोदशोध्यः)

(ग) २. नार्या for (नार्याः)

३. 'इति' से 'अध्यायः' तक अंकित नहीं, केवल समाप्तिसूचक ।। छः ।। ।।छः ।।
।। छः ।। अंकित है ।

(च) १. पंचाशत्त्रयोदशोध्यायः for (पंचाशस्त्रयोदशोध्यायः)

३. 'इति' से 'अध्यायः' तक लुप्त.

अथ स्फुटगत्युत्तराध्यायः

चतुर्दशः

भुजभागैः कोटिज्यां कोद्य[1]ंशैर्यैः करोति बाहुज्याम् ।
कोटिं[3] भुजेन बाहुं[4] क्योस्त्रावा[2] स्फुटगतिज्ञः[5] सः ॥ १ ॥
परमफलकेंद्रविकः[1] करोति कोटिछ्या[2] स्फुटं कर्णम्[4] ।
कर्णातिकोटिकोद्या[3] बाहुं वा स्फुटगतिज्ञः[5] सः ॥ २ ॥
केंद्रभुजकोटिजीवा परमफलज्ञः करोति यः कर्णम्[1] ।
स्वोच्चं स्वफल[2]स्पष्टं करोति यः स्फुटगतिज्ञः सः ॥ ३ ॥
द्युगुण[1]स्फुट[3]ग्रह[2]यो भुजकोटिज्ये फले विना ज्याभिः ।
ज्याभिर्विना फलधनुः करोति वा स्फुटगतिज्ञः[4] ॥ ४ ॥
इष्टश्विन्योदयिकान्[1] करोति यो मध्यमान्[4] ग्रहान्[2] स्पष्टान् ।
स्वोच्चस्फुटैर्ग्रहं यः करोति वा स्फुटगतिज्ञः[3] सः ॥ ५ ॥

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१. (घ) १. कोटचंशै (ग) (च) for (कोद्यंशैं) २. कोद्यावा (ग) (च) for (क्योस्त्राबा)
(ग) ३. कोटिभुजेन for (कोटिंभुजेन) ४. बाहु for (बाहुं)
(ङ) २. कोटचा वा for (क्योस्त्रा वा) ५. स्फुटगतिज्ञः for (स्फुगतिज्ञः)
२. (घ) १. विद्युः (ग) वित् यः for (केन्द्रविकः) २. ज्यया (ग) (ङ) for (छ्या)
(ग) ३. कोटिम् for (कोटि)
(च) १. विद्युः for (विकः) ४. कर्ण्यं for (कर्णम्)
३. कर्ण्यातकोटिकोद्या for (कर्णातिकोटिकोद्या) ५. ज्ञतिज्ञः for (गतिज्ञः)
(ङ) १. विद्यः for (विकः) ३. कोटिकोटचा for (कोटिकोद्या)
३. (च) १. कर्ण्यं for (कर्णं)
(ङ) २. सफलं for (स्वफलं)
४. (घ) १. द्युगणा (ग) सुगुणात् for (द्युगुण) २. ग्रहं (ग) (च) (ङ) for (ग्रह)
(ग) ३. स्फुटं (ङ) for (स्फुट) ४. +सः+ (च) (ङ)
(च) १. द्युगणा for (द्युगुण)
(ङ) १. द्युगणात् for (द्युगुण)
५. (घ) १. इष्टाश्विन्यौदयिकान् (ग) इष्टाश्विन्योदयिकान् for (इष्टश्विन्योदयिकान्)
२. मध्यमान् स्पष्टान् for (मध्यमान् ग्रहान् स्पष्टान्)
(घ) ३. स्पुगतिज्ञः for (स्फुटगतिज्ञः)
(च) १. इष्टाश्विन्यो for (इष्टश्विन्यो)
(ङ) ४. मध्यान् for (मध्यमान्)

संक्रान्तेरा[2]द्यंतौ ग्रहस्य यो राशिभतिथि[3]करणां[1]तान् ।
व्यतिपाताद्यंतौ वा यो वेत्ति स्फुटगतिज्ञः सः ॥ ६ ॥
व्यासदलमितरजीवाभुजको[3]द्यंशो क्रमज्यया[1] हीनम् ।
कोटिभुजज्या व्यासार्द्धकृतिविशेषात्पदं [2]चान्या ॥ ७ ॥
कोटिज्यया द्विगुणया गुणां[1]त्यफलज्यता[2] युतोनायाः ।
[6]मृगकर्क्यादौ [3]त्रिज्यां तत्फलकृति[4]युते [5]पदं कर्णः ॥ ८ ॥
त्रि[1]ज्यांत्यफल[3]त्वतियुतेः कर्णकृतेश्चांत[5]रेवशेषं यत् ।
द्विगुणात्यफल[4]हृतं तत्को[2]टीज्या बाहुजीवा[6]तः ॥ ९ ॥

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६. (घ) १. करणान्तात् (ग) (च) for (करणांतान्)
(ग) १. राद्यंतो for (राद्यंतौ) ३. तिथिक for (तिथि)

७. (घ) १. ज्येयाहीनाम् (च) for (ज्यया हीनम्) २. वान्या for (चान्या)
(ग) ३. कोटयंशोत्क्रम (च) for (कोद्यंशोक्रम)
(ङ) ३. कोटयंशोत्क्रम for (कोद्यंशोक्रम)

८. (घ) १. गुणयांत्यफल (ग) (च) for (गुणांत्यफल)
२. ज्यया (ग) (च) for (ज्यता)
३. त्रिज्यांत्यफल (ग) for (त्रिज्यां तत्फल) ४. युतेः (ग) (च) for (युतेपदं)
(च) ६. मृगकर्क्यादौ for (मृगकर्क्यादौ) ३. त्रिज्यांत्यफल for (त्रिज्यांतत्फल)
५. कर्ण्यः for (कर्णः)
(ङ) १. ऽन्त्यफलज्या गुणितया for (गुणांत्यफलज्यता)
३. त्रिज्यान्त्यफलज्या for (त्रिज्यांतत्फल) ४. युतेः for (युते)

९. (घ) १. त्रिज्यांत्यफत्वति for (त्रिज्यांत्यफलत्वति)
२. तत्कोटिज्या (च) (ङ) for (तत्कोटीज्या)
(ग) ३. कृति for (त्वति) ४. हृतं for (ह्लतं)
(च) १. त्रिद्यांत्य for (त्रिज्यांत्य) ३. फत्वतियुतेः for (फलत्वतियुतेः)
(ङ) ३. कृतियुतेः for (त्वतियुतेः) ५. तरेऽवशेषं for (नरेवशेषं)
६. जीवाऽतः for (जीवातः)

कथ्नामंडलतुल्यं प्रतिमंडलमध्यमवनिमध्यात्स्वेत् ।
त्स्वोच्चनीचवृत्तव्यासार्द्धे भिमुखमुच्चास्य ॥ १० ॥
प्रतिमंडलस्य परिधौ मध्यमभुक्त्या स्फुटग्रहो भ्रमति ।
मंदोच्चादनुलोमं शीघ्रात्प्रतिलोममवनिस्थाः ॥ ११ ॥
स्पष्टं पश्यति यस्मात् मध्याद्धनाधिकं स्वकक्षायाम् ।
तस्मात्तदन्तरफलमृणं धनं धने वा ग्रहे मध्ये ॥ १२ ॥
अंत्यफलज्ययात्स्वान्यदयोराद्यंतयोरूपरिकोटिः ।
द्वितीययोर्यतोधस्तदंतरैक्यं ततः कोटिः ॥ १३ ॥

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१०. (घ) १. कक्षा (ग) (च) (ङ) for (कथ्ना) २. मंलमध्य for (मण्डलमध्य)
३. खे (ग) (ङ) for (स्वेत्) ४. तत्स्वोच्चनीच (ग) (ङ) for (त्स्वोच्चनीच)
५. मुच्चस्य (ग) (च) for (मुच्चास्य)
(ग) ६. तुल्य (ङ) for (तुल्यं)
(च) ३. त्स्वेत for (त्स्वेत्)
(ङ) ५. ऽभिमुखमुच्चस्य for (भिमुखमुच्चास्य)

११. (घ) १. अवनिस्थः (ग) for (अवनिस्थाः)
(ग) २. स्पुटग्रहो for (स्फुटग्रहो)
(च) १. मवनिस्थः (ङ) for (मवनिस्थाः)

१२. (घ) १. मध्यादूनाधिकं (ग) (च) (ङ) for (मध्याद्धनादिकं)
(ग) २. 'धने' लुप्त है, (ङ) ।
(च) ३. यस्मान् for (यस्मात्) ।

१३. (घ) १. ज्याग्रात्स्यात् (ग) for (ज्ययात्स्वान्)
२. द्वितृतीययोः (ग) for (द्वितीययो)
(ग) ३. पदयो for (यदयो) ४. कोटि for (कोटिः)
(च) १. अंतफ (त्यु) फलज्याया for (अंत्यफलज्यया)
३. त्स्वात्यदयो for (त्स्वान्यदयो)
(ङ) १. ज्याग्रात् for (ज्ययात्) ३. स्यात्पदयो for (स्वान्यदयो)
२. द्वितृतीययो for (द्वितीययो) ३. रधस्तात् for (र्यतोधस्)

कोद्यांत्य[1]फलाद्यै[2]क्यं मकरादावंतरं कुलिरादौ[3] ।
तद्वाहुज्याकृत्योः संयोगपदं भवति कर्णः[4] ॥१४॥
प्रतिमंडलपदमाद्यं ग्रहत्रयं[1] सांत्यधनुरतोन्यच्च[2] ।
चक्र[5].द्धांतमतोन्यद्याद्य[3]भचक्रांतं[4] मंत्यमतः ॥ १५ ॥
त्रिमनेवांत्य[1]फलधनुर्युतमाद्यं नवममं[2] तृतीयपदमून ।
द्विचतुर्थेषु द्वादशभाग्नि[4]प्रतिमंडलपदानि ॥१६॥

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१४. (घ) १. कोटयंत्य (ग) for (कोद्यांत्य)
२. फलद्यैक्यं (ग) फलज्यैक्यं for (फलाद्यैक्यं)
३. कुलीरादौ (ग) (च) (ङ) for (कुलिरादौ)

(च) १. कोटयांत्य फलाद्यैकं for (कोद्यांत्यफलाद्यैकं) ४. कर्ण्यः for (कर्णः)

(ङ) १. कोटयन्त्य for (कोद्यांत्य) २. फलज्यैक्य for (फलाद्यैक्य)

१५. (घ) १. ग्रहत्रयं (ग) गृहत्रयं for (ग्रहत्रयं)
२. रतोऽन्यच्च (ग) रतोन्यश्च for (रतोन्यच्च)
३. मतोन्यद्व्याद्यभ (ग) for (मतोन्यद्याद्यभ)
४. चक्रांतमंत्यमतः (ग) for (चक्रांतमंत्यमतः)

(ग) ५. चक्रार्धंत for (चक्राद्धांत)
(च) १. गृहत्रयं (ङ) for (ग्रहत्रयं)
(ङ) ५. चक्र र्धमनेनोनं द्वितृतीयं चतुर्थमाद्यसमम् for (चक्राद्धांतमतोन्यद्याद्यभच-क्रांतं मंत्यमतः)

१६. (घ) १. त्रिभमेवांत्य for (त्रिमनेवांत्य) २. नवमभम् for (नवममं)
३. मूनम् (ङ) for (मून) ४. भानि for (भाग्नि)

(ग) यह श्लोक इस प्रति में नहीं है ।

(च) १. त्रिभमेवांत्य for (त्रिमनेवांत्य) ४. द्वदशभानि for (द्वदशभाग्नि)
(ङ) १. त्रिभमन्त्य for (त्रिमनेवांत्य) २. नवमं for (नवममं)
४. षड्द्वादशभानि for (षुद्वादशभाग्नि)

कर्णाहृते[1] व्यासार्द्धं भुजज्यया गुणितमाप्तधनुराद्यैः[2]।
प्रोहृच्यदला[3]द्वितये[4] षड्राशियुतं[5] तृतीयपदे ॥ १७ ॥
चक्रत्प्रोह्य[1] चतुर्थे स्फुटोच्चयो[4]रंतरं स्वमंदोच्चे[2] क्षेप्यम्[5]।
शीघ्रे शोध्यं तत्स्पष्टं[6] पूर्ववच्छेषम्[3] ॥ १८ ॥
मध्यस्फुटांतरकला बाहुफलं भवति तीक्ष्णकिरणस्य।
स्फुटभुक्तयार्कादीनां[1] भुजान्तरं क्षयधनं रविवत् ॥ १९ ॥

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१७. (घ) १. कर्णाहृतं (ग) (ङ) for (कर्णाहृते) २. राद्यैः (ग) राद्ये for (राद्यैः)
३. भदला (ग) (ङ) for (दला)

(ग) (वि० यहां यह श्लोक १६ की संख्या पर अंकित है।)

४. द्वितीये (ङ) for (द्वितये) ५. षड्राशयुतं for (षड्राशियुतं)

(च) १. हृतं for (हृते) ३. प्राकरभदला for (प्रोह्यदला)

(ङ) २. राद्ये for (राद्यैः)

१८. (घ) १. चक्रात्प्रोह्य (ग) (ङ) for (चक्रत्प्रोह्य)
२. मंदोच्चोत्क्षेप्यम् (ग) for (मंदोच्चे)
(वि० 'मंदोच्चे' पर श्लोकार्ध समाप्त।)
३. छेषम् for (वच्छेषम्)

(ग) ४. स्पुटोच्च for (स्फुटोच्चयो)
५. 'क्षप्यं' for (क्षेप्यं)
(वि० इससे द्वितीय पंक्ति का आरम्भ)
६. स्पष्टः (ङ) for (स्पष्टं)
(वि० इसकी श्लोक संख्या १७ है।)

(च) १. चक्रात्प्रोक्ष्य for (चक्रत्प्रोह्य) ६. तत्स्पष्ट for (तत्स्पष्टं)

(ङ) ३. पूर्ववत्शेषम् for (पूर्ववच्छेषम्)

(वि० श्लोक की दूसरी पंक्ति "क्षेपम्" शब्द से आरम्भ होती है।)

१९. (ग) (वि० इसकी श्लोक संख्या १८ है)

(च) १. भुक्तयार्क्कादीनां for (भुक्तयार्कादीनां)

(ङ) १. भुक्तयार्क्कादीनां for (भुक्तयार्कादीनां)

मंडलशेषात्[3] स्वोच्चं विशोध्य शेषं[4] चतुर्गुणालब्धम्[2]।
केंद्र[5] यदा निजिनगुणा[1] जीवा गतयेयगतयो यैः ।। २० ।।
छेदचतुर्थे[1] बाहुर्येयागतगतैस्तथा[2] कोटिः ।
प्राग्वदिनेन्दुभुजफलं[4] तथाफलं[5] भूसुतादिनाम्[3] ।। २१ ।।
फलचापकला गुणिते छेदे मंडलकलाह्लत लब्धम्[1] ।
मंडलशेषे पूर्ववद्रणधनमस्माद्[2] ग्रहः स्पष्टः ।। २२[3] ।।

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२०. (घ) १. गुणात् (ङ) for (गुणा) २. गतयेयैः (ग) गयेयैः for (गतयोयैः)
(ग) ३. शेखात् for (शेषात्) ४. शेखाश्च for (शेषं च)
५ पदानि for (यदानि) (च) (ङ)
(वि० इसकी श्लोक संख्या १६ है।)
(च) १. यै for (यैः)
(ङ) ४. सद्दशं for (शेषं) ६. चतुर्गुणाल्लब्धम् for (चतुर्गुणालब्धम्)
२. गतयेयैः for (गतयोयैः)

२१. (घ) १. चतुर्थेर्बाहुर्ये (ग) चतुर्थेर्बाहु for (चतुर्थे बाहुर्ये)
२. यगतागतगवे (गे) यगतागतगतै for (यागतगतै)
३. सुतादीनाम् (ग) (ङ) for (सुतादिनाम्)
(ग) ४. 'भु' लुप्त है। (वि० इसकी श्लोकसंख्या २० है।)
(च) १. चतुर्थेर्बाहुर्ये for (चतुर्थे बाहुर्ये) २. यगतागतगतैस्तथा (यागतगतैस्तथा)
३. सुतादीनां for (सुतादिनाम्)
(ङ) १. चतुर्थेर्बाहो for (चतुर्थेबाहु) २. येंयगता for (येंया)
५. मन्दफलं for (तथाफलं)

२२. (ग) १. कलाहृते ल्लब्धम् (ग) for (कलाह्लत लब्धम्)
२. पूर्ववद्दणधन (ग) (ङ) for (पूर्ववद्रण)
(वि०—यहाँ संख्याक्रम २२ के स्थान में २३ लिखा हुआ है)
(ग) यहाँ श्लोक संख्या २१ है। २२ वाँ श्लोक इसके स्थान पर निम्नांकित है—
भुजकोट्यंशो न गुणाभार्द्धांशातश्चतुर्थ भागोनैः ।
पंच द्वींदुखचंद्रैर्विभाजिता व्यासदलगुणिताः ।। २२ ।।
(च) १. हृतेल्लब्धं for (हृतलब्धम्) २. पूर्ववद्दणधन for (पूर्ववद्रणधन)
३. (वि० क्रमसंख्या २३ अंकित है।)
(ङ) १. कलाहृते for (कलाह्लत)

तज्ये[3] परमफलज्या संगुणितात्[1] फ फले विनाद्याभिः[2] ।
इष्टोच्चनीचवृत्तव्यासार्द्धं परमफलजीवा[4] ॥ २३ ॥

२३. (घ) वि० अतिरिक्त श्लोक —

तज्ये परमफलज्या संगुणितातफले विभुजकोट्यंशो न गुणा भार्द्धांशास्तच्चतुर्थे भागो नेः । पंचद्वींदुखचंद्रै विभाजिता व्यासदलगुणिताः ॥ २३ ॥

(वि० यह श्लोक यहाँ २३ संख्याक्रम पर पाया गया)

२३. (घ) (वि० इसकी क्रम संख्या २४ है ।)

१. तत्पले (ग) संगुणितास्ततफले for (संगुणितातफफले)

२. ज्याभिः (ग) (ङ) for (द्याभिः)

(ग) वि० अतिरिक्त श्लोक —

सतज्ये परमफलज्या संगुणितास्ततफले विना ज्याभिः ।
इष्टोच्चनीचवृत्तः व्यासार्द्धं परमफलजीवा ॥ २३ ॥

३. तत् ज्ये for (तज्ये)

(वि० इसकी क्रम संख्या २३ है ।)

(च) यहाँ पर यह पंक्तियाँ लुप्त हैं—इनके स्थान में निम्नांकित शब्द किसी अन्यलेख में-निम्नोपांत में अंकित हैं ।

"भुजकोट्यंशो गुणा भार्द्धांशास्तच्चतुर्थ भांतैः ।
पंचार्द्धी दुखचन्द्रै विभाजिता व्यासदलगुणिता ॥"

३. तद्ये for (तज्ये) १. संगुणितातफले for (संगुणितात् फ फले)

(वि० क्रमसंख्या २४ अंकित है ।)

(ङ) २३ वाँ श्लोक निम्नांकित है—

:भुजकोट्यंशोनगुणा भार्द्धांशास्तच्चतुर्थभागोनैः ।
पञ्चद्वींदुखचन्द्रैर्विभाजिता व्यासदलगुणिता ॥ २३ ॥"

'तज्ये······जीवा' की क्रमसंख्या २४ है ।

३. तज्ज्ये for (तज्ये) १. तत्फले for (त् फले)

इष्टज्या संगुणिता[1] पंचकयमलैक शून्यचन्द्रमसा[2]।
इष्टज्यापाद[3]युतव्यासार्द्धविभाजितालब्धम्[4] ॥ २४ ॥
नवतिकृतेः प्रोह्यपदं नवतेः संशोध्य शेषकला[1]।
एवं धनुरिष्टाया[2] भवति ज्यया[3] विना ज्याभिः[4] ॥ २५[5] ॥
इष्टो[1]दयिकभुजांतर[4]मित[2] व स्फुट मध्यमांतरकलाभिः।
वाश्वि[3]न्यौदयिकेषु स्वचर[5]प्राणैः स्वफलमेत्रम्[6] ॥ २६ ॥

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२४. (घ) (वि० इसकी क्रमसंख्या २५ दी गई है।)
१. संगुणिताः (ग) (च) (ङ) for (संगुणिता)
२. चन्द्रमसः (ग) शून्यचन्द्रसमः for (चन्द्रमसा)
(च) २. चन्द्रमसः for (चन्द्रमसा) ३. इष्टद्या for (इष्टज्या)
४. (वि०क्रमसंख्या २५ अंकित है।)
(ङ) (वि० इस श्लोक की क्रमसंख्या २५ है)
२. चन्द्रमसः for (चन्द्रमसा)

२५. (घ) १. कलाः for (कला) (ग) शेषभागकलाः or (शेषकला)
२. धनुरिष्टयो for (धनुरिष्टाया) ३. ज्याया (ग) (च) (ङ) for (ज्यया)
(वि०—इसकी संख्या २६ अंकित है)
(ग) ४. विज्याभिः for (विनाज्याभिः)
(च) १. शेषभागकलाः for (शेषकला) २. रिष्टया for (रिष्टाया)
५. (वि० क्रमसंख्या २६ अंकित है)
(ङ) १. शेषभागकलाः for (शेषकला) ४. विनाज्याभि for (विनाज्याभिः)
(वि० इसकी क्रमसंख्या २६ है)

२६. (घ) १. इष्टौदयिक (ङ) for (इष्टोदयिक)
२. मिनवत (ग) मिनवत् for (मितव)
३. नाश्विन्यौदयिकेषु (ग) नाश्विन्योदधिकेषु for (वाश्विन्यौदयिकेषु)
(ग) ४. भुजातर for (भुजांतर) ५. स्वरप्राणैः for (स्वचरप्राणैः)
(च) ६. (वि० यहां क्रमसंख्या २७ अंकित है) (ङ)
(ङ) २. वि० मिनवत् for (मितव) ७. मिनवत् for (मेत्रम्)
३. नाश्विन्यौदयिकेषु for (वाश्विन्यौदयिकेषु)

स्वोच्चं वि[1]शोध्य कृ[4]त्वा प्राग्वत्फलमृणधनं विपर्यस्वम्[2] ।
कार्या[3]मनष्टेस्पष्टे पु[5]नः पुर्नानि[6]श्चलो मध्यः ॥२७॥
मा[7]नार्द्धात् ष[5]ष्टिगुणाद्भुक्ति हृ[3]तान्नाडिकादिलब्धेन ।
राश्यंतान् प्रा[1]णादि पश्चा[2]देतोर्क[4]संक्रांतेः[6] ॥ २८ ॥
संक्रांति पु[1]ण्यकालो यल्लब्धं नाडिकादि तद्द्वि[4]गुणम् ।
स्नानजपहो[2]मादिकोत्र धर्मो विशिष्टफल[3] ॥ २९ ॥[4]

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२७. (घ) १. विविशोध्य (ग) स्वोच्चविशोध्य for (स्वोच्चं विशोध्य)
(वि० इसकी क्रमसंख्या २८ अंकित है)
(ग) २. विपर्यस्तम् (ङ) for (विपर्यस्वम्) ३. कार्यमनष्टे for (कार्यामनष्टे)
(च) ४. क्रत्वा for (कृत्वा) ५. षुनः for (पुनः)
६. (वि० यहां क्रमसंख्या २८ अंकित है) (ङ)
(ङ) १. स्वोच्चाद् for (स्वोच्चं) ३. कार्यमनष्टस्पष्टे for (कार्यामनष्टेस्पष्टे)

२८. (घ) १. प्रागादिः (ग) for (प्राणादि) २. पश्चांदंतोर्क (ग) for (पश्चादेतोर्क)
(वि० इसकी क्रमसख्या २९ अंकित है)
(ग) ३. हृता (ङ) for (हृता) ४. संक्रान्ते for (संक्रान्तेः)
(च) ५. षष्टी for (षष्टिः) १. प्रागादिः (ङ) for (प्राणादि)
२. पश्चादंतोर्क्संक्रांतेः for (पश्चादेतोर्कसंक्रांतेः)
६. (वि० यहां क्रमसंख्या २९ अंकित है) (ङ)
(ङ) २. पश्चादंतोऽर्क for (पश्चादेतोर्क) ७. मानार्धात् for (मानार्द्धात्)

२९. (च) १. पुण्यकालो (ग) (च) for (पुष्यकालो)
(वि० इसकी क्रमसंख्या ३० अंकित है)
(ग) २. होमदानादि (ङ) for (होमादि) ३. फलम् for (फल)
(च) ४. (वि० यहां क्रमसंख्या ३० अंकित है) (ङ) ।
(ङ) १. पुण्यकालो for (पुष्यकालो) ४. तद्द्विगुणम् for (तद्विगुणम्)
२. होमदानादिकोऽत्र for (होमादिकोत्र)
३. विशिष्टफलः for (विशिष्टफल)

एवं नक्षत्रांतातिथिकरणतो छशिप्रमाणाद्धात् ।
षष्टिगुणात् रविशशिनोभुक्तचंतर लब्धघटिकाभिः ।। ३० ।।
संक्रांतिस्थो यावत्करोति मिश्र फलं ग्रहस्तावत् ।
यस्मात्तस्मादिष्टो राद्यंतौ परिदरति लोकः ।। ३१ ।।
चक्रार्द्धेऽर्कशशियुतौ भिन्नायनयोरपक्रमच्चे ।
रविशशिनोः सममधुधृतयोगादिषु वच्च्यतिपातः ।। ३२ ।।

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३०. (घ) १. त्तिथि (ग) (च) for (तिथि) २. छसि (ग) शिशि for (छशि)
(वि० इसकी क्रमसंख्या ३१ है)
(ग) ३. करणी for (करणतो) ४. (च) (ङ) व्रवि for (त्रवि)
५. भुत्तचनर for (भुत्तचंतर)
(च) ३. करणांताछसि for (करणतोर्छशि) ६. क्रमसंख्यालुप्त
(ङ) ७. नक्षत्रान्तात् for (नक्षत्रान्ता) ३. करणान्ता for (करणतो)
२. च्छशि for (छशि) ५. भुंत्तचन्तर for (भुत्तचंतर)
(वि० इसकी क्रमसंख्या ३१ है) ।

३१. (घ) (वि० इसकी क्रमसंख्या ३२ है) १. विमिश्रं for (मिश्रं)
२. तस्माद्विष्टे (ग) तस्मादिष्टे for (तस्मादिष्टो)
३. परिहरति (च) (ङ) for (परिदरति)
(ग) ४. च्वाद्यंतौ for (राद्यंतौ) ५. (वि० क्रमसंख्या ३२ अंकित है) । (ङ)
(ङ) २. तस्माद्विष्टे for (तस्मादिष्टो)

३२. (घ) (वि० इसकी संख्या ३३ अंकित है) ।
१. कक्रार्द्धे (ग) चक्रार्धेर्के for (चक्रार्द्धेऽर्कं)
२. रपक्रमसमच्चे (ग) रूपक्रमसमत्वे for (रपक्रमच्चे)
३. योगद्विषवद्वातीपातः (ग) तद्वषवद्वयतीपातः for (योगादिषुवच्च्यतिपातः)
(च) २. रपक्रममच्चे for (रपक्रमच्चे)
३. योगाद्दिषुवद्वयतीपातः for (योगादिषुवच्च्यतिपातः)
४. (वि० क्रमसंख्या ३३ अंकित है) (ङ)
(घ) २. रपक्रमसमत्वे for (रपक्रमच्चे) ३. योगाद्विषदो for (योगादिषु)
४. व्यतीपातः for (वच्च्यतिपातः)

चक्रे वैधृतमेकायतस्थयोः[1] क्रांतिजीवयोः[5] साम्ये[6] ।
धन[2]रविगणि[3]योगादग्नि वदूनाधिक[7] कलभ्यः[4] ॥ ३३ ॥[8]
भुक्तै[1]क्यलब्धदिवसैः रवींदुपातायुतोनकाः स्वफलैः ।
[3]अर्कक्रान्तिज्याधनुरिंदो विक्षेप[2]युक्तोनम्[4] ॥ ३४ ॥
त्रिनवग्रहेंदु[1] क्रान्तिर्मेव[2] तुलादौ दिवाकरक्रांतः[3] ।
[4]उनायावदभावस्तावद्भावो न्यथा[5]र्केन्द्वोः[6] ॥ ३५ ॥[7]

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३३. (घ) १. मेकायस्थयोः (ग) मेकायनस्थयोः for (मेकायतस्थयोः)
२. इंधन (ङ) (ग) (च) for (धन)
३. मणि (ग) (च) (ङ) for (गणि)
४. कलाभ्यः (ग) (च) (ङ) for (कलभ्यः)
(वि० इसकी क्रमसंख्या ३४ अंकित है) (ङ)
(ग) ५. जीवाया: for (जीवयोः) (प्रथम पंक्ति समाप्त)
६. दूसरी पंक्ति का अंतिम पद ।
७. वरूनाधिक for (वदूनाधिक)
(च) ८. क्रमसंख्या ३४ अंकित है (ङ) ।
(ङ) १. मेकायनस्थयोः for (मेकायतस्थयोः)

३४. (घ) १. भुतचैक्य (ग) (च) (ङ) for (भुक्तैक्य)
२. विक्षेप (ग) (च) (ङ) for (विक्षेप)
(वि०-इसकी क्रम संख्या ३५ अंकित है)
(च) ३. अर्क्क for (अर्क)
४. (वि०—यहां क्रमसंख्या ३५ अंकित है) (ङ)
(ङ) ५. दिवसै for (दिवसैः)

३५. (घ) १. त्रिनवगृहेंदु (ग) (च) (ङ) for (त्रिनवग्रहेंदु)
२. मेंष (ग) (च) (ङ) for (मेंव)
४. ऊना (ग) (च) (ङ) for (उना) ५. ऽन्यथा (ङ) for (न्यथा)
(वि०—इसकी क्रमसंख्या ३६ अंकित है ।)
(च) ६. र्क्केंद्वोः for (र्केन्द्वोः)
७. (वि०—यहां क्रमसंख्या ३६ अंकित है) (ङ)
(ङ) ३. दिवाकरक्रान्तेः for (दिवाकरक्रान्तः)

व्यतिपात[1]योपक्रमयो[2]र्दिवसाम्ये [5]वैधृतं दिगन्यत्वे ।
अधिको[4] द्यूनः कल्पो[7] दिग्भेदे[3]पक्रमः शशिनः ॥ ३६[6] ॥
मेष[4]तुलादाविन्दोरपक्रमेल्यपक्रमाद्दुने[1] ।
एष्यत्यधिके[4] [2]तीतो विपरीतः कार्कि[3]मकरादौ ॥ ३७[5] ॥
क्रान्त्योर्युतिरन्यदिशोरेकदिशोरन्तरं व्यति[2]पाते ।
एकादशो[1] युतिरंतरमन्यदिशो वैधृते[4] प्रथमः ॥ ३८[3] ॥

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३६. (घ) (वि०—इसकी क्रमसंख्या ३७ अंकित है)
१. व्यतिपातोपक्रमयो (ग) व्यतीपातोपक्रमयो for (व्यतिपातयोपक्रमयो)
२. दिक्साम्ये (ग) दिक्साम्ये (च) for (दिवसाम्ये)
३. दिग्भेदे (ग) (च) for (दिग्भेदे)
(ग) ४. अधिकाप्यूनः for (अधिकोद्यूनः)
(च) १. व्यतिपातोपक्रमयो for (व्यतिपातयोपक्रमयो)
५. वैद्धृतं for (वैधृतं) ६. (क्रमसंख्या ३७ अंकित है) (ङ)
(ङ) १. व्यतिपातोऽपक्रमयो for (व्यतिपातयोपक्रमयो)
२. दिक्साम्ये for (दिवसाम्ये) ५. वैधृतो for (वैधृतं)
४. न्यूनः for (द्यूनः) ७. कल्प्यो for (कल्पो)
३. ऽपक्रमः for (पक्रमः)

३७. (घ) (वि०—इसकी क्रमसंख्या ३८ है)
१. दूने (ग) द्यूने for (दुने) २. ऽतीतो for (तीतो)
३. कर्कि (ग) कर्क्कि for (कार्कि)
४. मेतुला for (मेषतुला)
(च) १. दूने for (दुने) ३. कर्क्किमकरादौ for (कार्किमकरादौ)
५. (वि०—यहां क्रमसंख्या ३८ अंकित है) (ङ)
(ङ) १. दूने for (दुने) २. त्यधिकोऽतीतो for (त्यधिकेतीतो)
३. कर्क for (कार्कि)

३८. (घ) (वि०—इसकी क्रमसंख्या ३६ अंकित है)
१. एकदिशो (ग) एदिशोर्युति for (एकादशोयुति)
(ग) २. व्यतीपाते (ङ) for (व्यतिपाते)
(घ) १. एकदिशोर्युति (ङ) for (एकादशोयुति)
३. (वि०—यहां क्रमसंख्या ३६ अंकित है) (ङ)
(ङ) ४. वैधृते for (वैधृते)

एवं द्वितीयराशियुतिहीनै रिष्टनाडिकास्वफलैः ।
एष्यदतीत वा यदिराशिद्वयमपि तदंतरकम् ॥ ३९ ॥
छेदोन्यथा तदैक्यं घातस्येष्टघटिका प्रथमराश्योः ।
फलघटिकाभिर्मध्यं द्वयोरपि प्रथमराशिवशात् ॥ ४० ॥
तात्कालिकैर्ग्रहैरसकृदिष्टघटिकाफलोनयुक्तै स्तैः ।
प्राग्वत्प्रथमे छेदः प्रमाणयोगार्द्धलिप्तानाम् ॥ ४१ ॥
इष्टघटिकागुणानामसकृत फलनाडिकाभिराद्यंतैः ।
व्यतिपापवैधृतानयनमन्यतंत्रेषु न ब्राह्म्यात् ॥ ४२ ॥

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३९. (घ) (वि०—इसकी क्रमसंख्या ४० अंकित है)
१. एष्यदतीनं for (एष्यदतीतं)
(च) २. नाडिकाः for (नाडिका) १. ऐष्यदतीतं for (एष्यदतीतं)
३. (वि०—यहां क्रमसख्या ४० अंकित है) (ङ)
(ङ) ४. र्युतहीनै for (युतिहीनै)
४०. (घ) (वि०—इसका संख्याक्रम ४१ है)
१. प्रमराशिवशात् for (प्रथमराशिवशात्)
(ग) २. घतस्येष्ठ for (घातस्येष्ट) ३. द्वरपि for (द्वयोरपि)
(च) ४. (वि०—यहां क्रमसंख्या ४१ अंकित है) (ङ)
४१. (घ) (वि०—इसकी क्रमसंख्या ४२ है)
१. फलोनक्तै स्तैः for (फलोनयुक्तै स्तैः)
२. प्रथमच्छेदः (ग) प्रमच्छेदः for (प्रथमेच्छेदः)
(च) ३. रसक्रदिष्ट for (रसकृदिष्ट) ४. (वि०—यहां क्रमसंख्या ४२ अंकित है) (ङ)
(ङ) २. प्रथमश्छेदः for (प्रथमेछेदः)
४२. (घ) (वि०—इसकी क्रमसंख्या ४३ है)
१. असक्रतफल (ग) for (असकृतफल) २. राद्यंतो (ग) for (राद्यंतैः)
३. व्यतिपात (ग) व्यतीपात (ग) व्यतीपात for (व्यतिपाप)
४. ब्राह्मात् (ग) ब्रह्मात् for (ब्राह्म्यात्)
(ग) ५. गुणनाम् for (गुणानाम्)
(च) १. मसक्रत्फल for (मसकृतफल) ४. ब्राह्मात् for (ब्राह्म्यात्)
६. (वि०—क्रमसंख्या ४३ अंकित है) । (ङ)
(ङ) १. असकृत् for (असकृत) २. राद्यन्तौ for (राद्यंतैः)
३. व्यतिपात for (व्यतिपाप) ४. ब्राह्मात् for (ब्राह्म्यात्)

रविर्बिंबमेकमार्गाछ्शिबिंबापक्रमे भवति यावत् ।
तावत्फलं तदुक्तं तद्भावो तत्फलाभावः ॥ ४३ ॥
ग्रहकक्ष्यायनतुल्याः कक्षास्तन्मंदशीघ्रपातानाम् ।
यस्मात्तस्मान्न पृथकक्षाः कल्प्याश्चलोच्चाद्याः ॥ ४४ ॥
पौलिशरोमकवाशिष्ट सौरपैतामहेषु यत्प्रोक्तम् ।
तन्नक्षानयनं नार्यभटोक्तं तदुक्तिरतः ॥ ४५ ॥

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४३. (घ) (वि०—इसकी क्रमसंख्या ४४ है)
१. मार्ग्रा (ग) मार्ग्रात शशि for (मार्गाछ्शि)
२. तदभावे (ग) तद्भावे for (तद्भावो)

(ग) ३. बिंबापक्रमो for (बिंबापक्रमे) ४ तावत्पलं for (तावत्फलं)
५. तत्फलोभावः for (तत्फलाभावः)

(च) २. तदभावे for (तद्भावो) ६. (वि०—क्रमसंख्या ४४ अंकित है) (ङ)

(ङ) १. मार्गाच्छ्शि for (मार्गाछ्शि) २. तदभावे for (तद्भावो)

४४. (घ) (वि०—इसकी क्रमसंख्या ४५ है)
१. पृथक्कक्षाः (ग) पृथक् कक्ष्या for (पृथकक्षाः)
२. कल्प्याश्चलोच्चाद्याः (ग) कल्पाचलोच्चाद्यात् for (कल्प्याश्चलोच्चाद्याः)

(ग) ३. ग्रहकक्षायन तुल्या for (ग्रहकक्ष्यायनतुल्याः) ४. तस्मात्तते for (तस्मान्न)

(च) १. पृथक्कक्षाः for (पृथकक्षाः) ५. (वि० क्रमसंख्या ४५ अंकित है) (ङ)

(ङ) ३. कक्षयैव for (कक्ष्यायन) १. पृथक् कक्षा for (पृथकक्षाः)
७. तुल्या कक्षा for (तुल्याःकक्षा) २. कल्प्या for (कल्प्याश्)
७. स्तनमंद शीघ्र for (तन्मन्द) ८. चलोचाद्या for (चलोच्चाद्याः)

४५. (घ) (वि०—इसकी क्रमसंख्या ४६ है)
१. तन्नक्षत्रानयनम् (ग) for (तन्नक्षानयनं)

(ग) २. पौलश for (पौलिश) ३. सौर्य for (सौर)

(च) १. तन्नक्षत्रानयनं for (तन्नक्षानयनं) ४. (यहां क्रमसंख्या '४६' अंकित है।)

(ङ) ५. वासिष्ठ for (वाशिष्ठ)

अध्वर्द्धार्द्ध[1] क्षेत्रान्यूडुनि[2] षट्[4] षट्[3] भवन्ति पञ्चदशाः[5] ।
ऋक्षाणि समक्षेत्राण्यभिजिद्भोगो भवत्येकः ॥ ४६[6] ॥
केशादित्यविशाखा[5] प्रोष्ट[6] पदार्यम्ल[4] वैश्वदेवाग्नि[1] ।
षट् षट् ज्येष्टाभरणी स्वात्यर्द्धा[2] त्रारूणाश्लेषा[3] ॥ ४७[7] ॥
पंचदशात्रानुक्ता न्येको भिजदुक्त[1]रक्ष[5]भोगोन्यः[2] ।
तन्मानं[3] नाक्षत्रं दुरधिगमं मंदबुद्धिनाम्[4] ॥ ४८[6] ॥

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४६. (घ) (वि० इसकी क्रमसंख्या ४७ है)

१. अध्यर्द्धार्द्ध (ग) (च) for (अध्वर्द्धार्द्ध)

२. क्षेत्राण्युड्डनि (ग) for (क्षेत्रान्यूडुनि) ३. पट् (ग) षड् for (षट्)

(ग) ४. 'षट्' पद लुप्त है ५. दशः for (दशाः)

(च) २. क्षेत्राण्युड्डनि for (क्षेत्रान्यूडुनि) ३. पट् for (षट्)

६. (यहां क्रमसंख्या ४७ अंकित है।) (ङ) ।

(ङ) अध्यर्धानि भवन्ति षड् नक्षत्राण्युड्डनि षडर्धानि ।
पञ्चदश समक्षेत्राण्यभिजिद्भोगो भवत्येकः ॥४७॥

for

"अध्वर्द्धार्द्ध क्षेत्रान्यूडुनि षट् षट् भवन्ति पञ्चदशाः ।
ऋक्षाणि समक्षेत्राण्यभिजिद्भोगो भवत्येकः ॥ ४६॥

४७. (घ) (वि० इसकी क्रमसंख्या ४८ है)

१. वैश्वदेवानि (ग) (च) (ङ) for (वैश्वदेवाग्नि)

२. स्वात्यार्द्रा (ग) for (स्वात्यर्द्धा) ३. श्लेषाः (ङ) for (श्लेषा)

(ग) ४. मदार्यम्ल for (पदार्यम्ल)

(च) ५. विशाषा for (विशाखा) ६. प्रौष्ट for (प्रोष्ट)

२. स्वात्यार्द्धा for (स्वात्यर्द्धा) ३. श्लेषाः (ङ) for (श्लेषा)

७. (वि० —यहां क्रम संख्या अंकित नहीं है)

५. पदार्यम्ण for (पदार्यम्ल) २. स्वात्यार्द्रा for (स्वात्यर्द्धा)

४८. (घ) (वि० —इसकी क्रमसंख्या ४९ है)

१. ऽभिजिदुक्त (ङ) for (भिजिदुक्त)

२. भोगोऽन्यः (ग) भोगान्यः for (भोगोन्यः) ३. तात्मानं for (तन्मानं)

४. मंदबुधीनाम् (ग) (च) मंदबुद्धीनां for (मंदबुद्धिनाम्)

(ग) ५. ऋक्ष (ङ) for (रक्ष) (च) ३. तत्मानं for (तन्मानं)

६. (वि० —यहाँ क्रमसंख्या ४९ अंकित है) (ङ)

(ङ) ३. यस्मात् तन्नक्षत्रं for (तन्मानं नाक्षत्रं) ४. मन्दबुद्धीनाम् for (मंदबुद्धिनाम्)

अध्यर्द्धा[2] समक्षेत्राणां मध्यगते[3] लिप्तिकाः शशिनः ।
अध्यर्द्धार्द्धैक[4]गुणा भभोगलिप्तास्तदैक्योना[1] [5] ॥ ४९ ॥
मंडललिप्ताः शेषो भोगोभिजित्[1] शशांक[2] भगणा[3] वा ।
त्रिघनगुणाः संशोध्याः कल्पदिनेभ्यो यदवशेषम् ॥ ५०[4] ॥
तद्भगणैर्दिनभोगो[1] भिजितो भभोगलिप्तोना[3]ः ।
भानि ग्रहभुक्त[4]कला गतगम्या गतिहृता[2] दिवसाः[5] ॥ ५१[6] ॥
भफलं प्रोक्तमभिजितो मंगलपात्रासु[3] संहिताकारैः ।
यैस्तद्भोगोनोक्ता[1]स्ते गणकाः संहिता[2]बाह्याः ॥ ५२[4] ॥

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४९. (घ) (वि०—इसकी श्लोक संख्या ५० अंकित है)
१. तदैक्योनाः (च) (ङ) for (तदैक्योना)
(ग) २. अध्यद्धार्द्ध for (अध्यर्द्धा) ३. मध्यगति (ङ) for (मध्यगते)
(च) ४. अध्यर्ध्यार्द्धैक for (अध्यर्द्धार्द्धैक)
५. (वि०—यहां क्रमसंख्या ५० अंकित है) (ङ)
(ङ) २. अध्यर्धार्ध for (अध्यर्द्धा) ४. अध्यर्धार्धैक for (अध्यर्द्धार्द्धैक)

५०. (घ) (वि०—इसकी क्रमसंख्या ५१ है)
१. भोगोऽभिजित् (ग) भोगोभिजितः for (भोगोभिजित्)
(ग) २. शशी for (शशांक) ३. भगणैर्वा for (भगणावा)
(च) ४. (वि०—यहां क्रमसंख्या ५१ है) (ङ)
(ङ) १. ऽभिजितोभोगः for (भोगोभिजित्)

५१. (घ) (वि०—इसकी क्रमसंख्या ५२ है)
१. भुक्तिर्भोगाभिजितो (ग) दिनभुक्तिर्भोगो for (दिनभोगो)
२. हृता (ग) (च) for (हृता)
(ग) ३. लिप्तोनाम् for (लिप्तोनाः) ४. भुक्ति for (भुक्त)
५. दिवसा for (दिवसाः)
(च) ६. (वि०— यहां क्रमसंख्या ५२ है) (ङ)
(ङ) १. ऽभिजितो for (भिजतो) ७ + भोगो +

५२. (घ) (वि० इसकी क्रमसंख्या ५३ है) १. नोक्तस्ते (ग) (ङ) for (नोक्तास्ते)
(ग) २. सहिता for (संहिता)
(च) ३. यात्रासु for (पात्रासु) ४. (वि०—यहां क्रमसंख्या ५३ अंकित है) (ङ)
(ङ) ३. यात्रासु for (पात्रासु)

अर्घ्यार्द्धक्षेत्राणि संहिता स्वभिहितानि गर्गाद्यैः ।
यस्मादुडुनितस्मान्नार्यभटोक्तं तदानयनम् ॥ ५३ ॥
आर्याणां पञ्चांशच्चतुर्भिरधिका चतुर्दशोऽध्यायः ।
चतुर्दशोध्यायः समाप्तः

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५३. (घ) (वि०—इसकी क्रमसंख्या ५४ है)
१. अध्यर्द्धा (ग) अध्यर्द्धादि for (अर्घ्यार्द्ध) २. क्षत्रणि for (क्षेत्राणि)
(ग) ३. यस्मादुड्डति (च) for (यस्मादुडुनि)
(च) १. अध्यर्द्धार्द्धक्षेत्राणि for (अर्घ्यार्द्धक्षेत्राणि)
४. (वि०—यहां क्रमसंख्या ५४ अंकित है) ।
(ङ) १. अध्यर्धादि for (अर्घ्यार्द्ध) ३. यस्मादुड्डनि for (यस्मादुडूनि)
५४. (घ) १. चतुर्भि (ग) च्चतुर्भि for (चतुर्भि) २. चतुर्द्दशो (ग) for (चतुर्दशो)
(ग) 'चतुर्दशो' से 'समाप्तः' तक अंकित नहीं है । इसकी दूसरी पंक्ति निम्नांकित है
'स्फुटगतिरुत्तरमन्या दिशा व्यूहयत्प्रस्नात् ॥५४॥
(च) १. पञ्चाशच्चतुर्भिरधिका for (पञ्चांशच्चतुर्भिरधिका)
२. चतुर्द्दशोध्यायः for (चतुर्दशोऽध्यायः)
३. 'छ' for (चतुर्दशोध्यायः समाप्तः)
(ङ) १. च्चतुर्भि for (च्चतुर्भि)
४. +स्फुटगत्युत्तरमन्यान् दिशाऽनयया ऽभ्युपगमेत् प्रश्नान् ॥५५॥
३. इति स्फुटगत्युत्तराध्यायश्चतुर्दशः for (चतुर्दशोऽध्यायः समाप्तः)

अथ त्रिप्रश्नोत्तराध्यायः

पञ्चदशः

स्फुटगत्यु[7]त्तरमन्या दिशानया[8]प्पूहयेत्प्रश्न[1]म्।[2]
यो[3]ह्लपूर्वापरयोस्तुल्यछायांगुलाग्रयो बिन्दु[4]।
वि[5]क्ष्याक्रांन्त्याक्षांशै वि[6]ना दिशो वेत्ति गणकः सः ॥ १ ॥
त्रि[1]छायाग्रज्ञो यः क्रान्त्य[3]क्षार्के विना दिशो भ्रमणम्।
छायाग्रस्य दि[2]नार्द्धे छायां वा वेत्ति गणकः सः ॥ २ ॥
यः[3] छायाग्रं दृष्ट्वा क्रांत्य[4]क्षज्ञो दिशो विजानाति।
शं[5]कुछायाभ्रमणे दि[1]क्ज्ञो वा वेत्ति गणकः स[2]ः ॥ ३ ॥

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१. (घ) १. प्रश्नात् (च) for (प्रश्नम्) २. (वि०—यहाँ पर समाप्तिसूचक चिह्न है)
३. योऽह्न (ग) येह्नः for (योह्न) ४. बिंदू (ग) बिंदुः for (बिंदु)
५. वीक्ष्य (ग) for (विक्ष्य) ६. विना (ग) for (विना)
(ग) ७. स्फुटगतिरुत्तर for (स्फुटगत्युत्तर)
८. व्यूयत्प्रस्नात् ॥ ५४ ॥ for (प्पूहयेत् प्रश्नम्)
(च) ३. योऽह्न for (योह्न) ५. विक्ष्य for (विक्ष्या)
४. बिंदू for (बिंदु) ६. विना for (विना)
(ङ) ३. योऽह्न for (योह्न) ४. विन्दु for (बिंदु)
५. बीक्ष्य for (विक्ष्या) ७. क्रान्त्यक्षांशै for (क्रान्त्याक्षांशैं)
६. विना for (विना)

२. (घ) १. त्रछाया for (त्रिछाया) २. दि अर्द्धे छायां (ग) दिनार्द्ध for (दिनार्द्धे)
(ग) ३. क्रांति क्षार्के विना for (क्रान्त्यक्षार्के विना)
(च) ३. क्रान्त्यक्षार्क्के for (क्रान्त्यक्षार्के)
(ङ) १. त्रिच्छाया for (त्रिछाया) ३. क्रान्त्यक्षार्के विना for (क्रान्त्यक्षार्के विना)
२. दिनार्धच्छायां for (दिनार्द्धे छायां)

३. (ग) १. दिज्ञो for (दिशो) २. "सः" यहाँ यह पद लुप्त है
३. यश्छायाग्रं for (यः छायाग्रं)
(वि० इसकी श्लोक संख्या ४ है। तीन की संख्या का श्लोक लुप्त है।)
(च) ४. क्रत्यक्षज्ञो for (क्रांत्यक्षज्ञो)
(ङ) ३. यश्छायाग्रं for (यः छायाग्रं) १. दिग्ज्ञो for (दिक्ज्ञो)
५. शंकुच्छाया for (शङ्कु छाया)

दृष्ट्वा विषुवछायां[४] लम्बश्नेज्ये[१] करोति यो बहुधा ।
मध्यछायार्कज्ञो[३] श्नांशान्यो[२] वेत्ति गणकः सः ।। ४ ।।
यश्चरखंड[१]कलंकोदया[५]द्विजानाति लग्नमुदयैः स्वैः ।
लग्ना[२] घटिका छायांगत[३] शेषनताच्च[४] गणकः सः ।। ५ ।।
गतशेषनता घटिका छायातो[३] भिष्ट[१]दिनदलछायां[४] ।
बहुधार्कक्रान्त्यश्नान[२] दृष्ट्वा यो वेत्ति गणकः सः ।। ६ ।।

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४. (घ) १. लंबक्षोज्य (ग) for (लंबश्नेज्ये)
२. ऽक्षांशान् (ग) क्षांशान् for (श्रांशान्)

(ग) (वि० इसकी श्लोक संख्या ५ है)

(च) १. लंवक्षेज्ये for (लंबश्नेज्ये) ३. मध्यछायाऽक्र्कज्ञो for (मध्यछायार्कज्ञो)
२. क्षांशान् for (श्रांशान्)

(ङ) ४. विषुवच्छायां for (विषुवछायां) १. लंबाक्षज्ये for (लंबश्नेज्ये)
३. मध्यच्छाया for (मध्यछाया) २. ऽक्षांशान् for (श्रांशान्)

५. (घ) १. खंड (ग) for (खंडकलं) २. लग्नाद्घटिका (ग) for (लग्नाघटिका)

(ग) (वि० इसकी श्लोक संख्या ६ है)
३. श्छाया for (छायांगत) ४. नताश्च (च) for (नताच्च)

(च) २. लग्नाद्घटिका for (लग्नाघटिका) ४. नत्ताच्च for (नताच्च)

(ङ) १. खण्डक for (खंडक) ५. लङ्कोदयान् for (लङ्कोदयाद्)
२. लग्नाद् for (लग्ना) ३. घटिकाश्छायां for (घटिकाछायां)

६. (घ) १. ऽभीष्ट (ग) भीष्ट for (भिष्ट) २. क्रान्त्यक्षान् (ग) for (क्रांत्यश्नान)

(ग) ३. श्छायातो (ङ) for (छायातो) ४. छायाः for (छायां)
(वि० इसकी श्लोक संख्या ७ है)

(च) १. ऽभीष्ट (ङ) for (भिष्ट)
२. बहुधार्क्कक्रान्त्यक्षान् for (बहुधार्कक्रान्त्यश्नान)

(ङ) ४. दलच्छायाम् for (दलछालां)
२. बहुधा क्रान्त्यर्काक्षान् for (बहुधार्क क्रान्त्यश्नान)

क्रांतिज्ञः[1] सममंडल शंकु[2]कर्ण[3] वयोश्नलंबज्ञः[4] ।
जानाति[5] कोणशंकु[6]छाया घटिकाः स तंत्रज्ञः ॥ ७ ॥
शंकुतलप्राच्यपरांतरद्वयं विक्षयो[1] विजानाति ।
विषुवछायामेकं[4] द्रष्ट्वादित्यं[2] च गणकः[3] सः ॥ ८ ॥
पातल[5]शंकुमुदयेंदुस्ते[1] वा दृग्ज्यां खे विजानाति[3] ।
द्रक् पाताल[2] द्रक्शंकोः[6] पृथक् तले वा स तंत्रज्ञः[4] ॥ ९ ॥

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७. (घ) १. कांतिज्ञः for (क्रांतिज्ञः) २. शंकुं (च) (ङ) for (शंकु)
३. कर्णः (च) for (कर्ण)
४. वयोक्षलंबज्ञः (ग) च योक्षलंबज्ञः for (वयोश्नलंबज्ञः)
५. जानाति जानाति for (जानाति) ६. शंकुं for (शंकु)
(ग)(वि०— इसकी श्लोक संख्या ८ है)
(च) ४ वयोक्षलंबज्ञः for (वयोश्नलंबज्ञः)
(ङ) ३. कर्णं च for (कर्णं व) ४. योश्रलंबज्ञः for (योश्नलम्बज्ञः)
६. शंकुच्छाया for (शंकुछाया)

८. (घ) वीक्ष (ग) वीक्ष्य for (विक्षयो)
२. दृष्ट्वादित्यं (ग) (च) for (द्रष्ट्वादित्यं)
(ग) (वि०—इसकी श्लोकसंख्या ९ है)
(च) १. वीक्ष for (विक्ष) ३. व for (च)
(ङ) १. वीक्ष्य for (विक्ष) ४. विषुवच्छाया for (विषुवछाया)
२. दृष्ट्वाऽऽदित्यं for (द्रष्ट्वादित्यं)

९. (घ) १. मुदयेऽस्ते (ग) मुदयेस्ते for (मुदयेंदुस्ते)
२. दृग्पावालगशंक्वोः (ग) दृग्पातालगशंकुकोः for (द्रक्पाताल द्रक्शंकोः)
(ग) ३. विजानाति for (विजानाति)
४. तत्रज्ञः for (तंत्रज्ञः) ५. पाताल for (पातल)
(वि०—इसकी भी श्लोकसंख्या ९ है)
(च) ५. पाताल for (पातल) २. दृग्पाताल for (द्रक्पाताल)
६. द्रग्शंक्वोः for (द्रक्शंकोः)
(ङ) ५. पाताल for (पातल) २. दृक्पाताल for (द्रक्पाताल)
१. मुदयेऽस्तो for (मुदयेन्दुस्ते) ३. खेविजानाति for (खे विजानाति)
६. गशङ्क्वोः for (द्रक्शंकोः)

दिनगतशेषप्राणैरिष्टार्को दिनदलान्नतैरथवा ।
भवति सममंडले यैर्यस्तान् कथयति स तंत्रज्ञः ॥ १० ॥
सममंडलगः प्राणैदिनगत शेषैं नतै द्दिनार्द्धाद्वा ।
यैं भर्वति ज्ञात्वा तान्योऽर्कं कथयति स तंत्रज्ञः ॥ ११ ॥
यः सममंडलशंकुकर्णं व वीक्ष सूर्यमानयति ।
रविसममंडलशंकुज्ञो क्षं कथयति स तंत्रज्ञः ॥ १२ ॥
रविलग्नांतर घटिका विनोदयैर्लग्नमिष्टघटिकाभिः ।
वेत्ति चरार्द्धादिक्षं योर्कज्ञो वा स तंत्रज्ञः ॥ १३ ॥
अक्षचरार्द्धज्ञार्कं छायातो यश्चरार्द्धमिष्टायाः ।
इष्टचरार्द्धादथवा छायां कथयति स तंत्रज्ञः ॥ १४ ॥

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१०. (घ) १. रिष्टाऽर्को (ग) रिष्टाऽर्को for (रिष्टार्को)
(ग) २. दिनगते for (दिनगत) ४. दिनदलान्नतेरथवा for (दिनदलान्नतैरथवा)
५. समंडले for (सममंडले) ६. तत्रज्ञः for (तंत्रज्ञः)
(च) १. ऽर्क्को for (र्को)
११. (घ) १. र्नतै (ग) (च) (ङ) for (नतै) २. दिनार्द्धाद्वा (च) for (दिनार्द्धाद्वा)
(ग) ३. सममंडलगं for (सममंडलगः) ४. यैंभंवति (च) for (यैंभर्वति)
५. नूयोर्कं for (न्योऽर्कं)
(च) ५. तान्योऽर्क्कं for (तान्योऽर्कं)
(ङ) १. दिनार्धाद्वा for (दिनार्द्धाद्वा) ६. योऽर्कं for (योऽर्कं)
१२. (घ) १. शंकु (ग) (ङ) for (शंकु) २. वा (च) (ङ) for (व)
३. वीक्ष्य (च) (ङ) for (वीक्ष) ४. कथति (च) for कथयति)
(ग) ५. समंडल for (सममंडल)
(ङ) ६. ऽक्षं for (क्षं)
१३. (ग) १. घटिको for (घटिका) २. लग्न for (लँग्न)
(च) ३. योऽर्क्कज्ञो for (योर्कज्ञो)
(ङ) ३. योऽर्कज्ञो for (योर्कज्ञो)
१४. (घ) १. यस्यरार्द्धं (ग) यश्चचरार्ध for (यश्चरार्द्धं)
२. कथति for (कथयति)
(ग) ३. चरार्द्धंज्ञो for (चरार्द्धज्ञार्कं) ४. चरार्द्धंदथवा for (चरार्द्धादथवा)
(च) ३. ज्ञार्क्कं for (ज्ञार्कं)
(ङ) ३. चरार्धज्ञोऽर्कं for (चरार्द्धज्ञार्कं) ४. चरार्धादथवा for (चरार्द्धादथवा)

मध्यछायातो[५] क्षविदानयति[१] रविवाक्[६][२] रज्ञोश्नं ।
योग्रार्कज्ञो[३] लंबाक्षज्ये[४] कथयति स तंत्रज्ञः ॥ १५ ॥
उदयेस्तमये[६] चाग्रां[१] वेत्ति दिनार्द्धे नतोन्नतज्ययः[२] ।
ताभिर्विषुवछाया[४] श्नज्या[३]लंबान्[५] स तंत्रज्ञः ॥ १६ ॥
दिनरात्र्यर्धे[४] यश्चरदलाद्[५] विना स्वेकरोति[६] वाताभ्यां ।
अक्षावलंबकौ वा नस्तमयार्का[१]त्[३]स तंत्रज्ञः ॥ १७ ॥

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१५. (घ) १. छायातोक्षविदानयति (ग) तोऽक्षविदानब्दि for (छायोतोक्षविदानयति)
२. रविवाकरज्ञोक्षम् (ग) रविदिवाकरज्ञोऽक्षम् for (रविदिवाकरज्ञोऽक्षम्)
३. लोबाक्षज्ये for (लम्बाक्षज्ये)

(च) २. रविवाक्रज्ञोक्षं for (रविवाक्रज्ञोश्नं) ३. योग्रार्क्कज्ञो for (योग्रार्कज्ञो)
४. लंबाक्ष्यज्ये for (लंबाक्षज्ये)

(ङ) ५. मध्यच्छायातो for (मध्यछायातो)
१. ऽक्ष for (क्ष) ३ योऽग्रार्कज्ञो for (योग्रार्कज्ञो)
६. रवि for (रवि) २. दिवाकरज्ञोऽक्षम् for (वाक्रज्ञोश्नं)
४. लम्बाक्षांशान् for (लम्बाक्षज्ये)

१६. (घ) १. वाग्रां (ग) (ङ) for (चाग्रां) २. ज्ये (ग) ज्येयः for (ज्ययः)
३. क्षज्या (ग) क्षप्या for (श्रज्या)

(ग) ४. विषुवा for (विषुवछाया) ५. लंबात् for (लंबान्)

(च) ३. क्षज्या for (श्नज्या)

(ङ) ६. उदयेऽस्तमये for (उदयेस्तमये) २. ज्ये यः for (ज्ययः)
४. विषुवच्छाया for (विषुवछाया) ३. क्षज्या for (श्रज्या)

१७. (ग) १. नस्तमयार्के for (नस्तमयार्कात्) २. नस्तमयार्को for (नस्तमयार्कात्)
३. न स for (त्स)

(च) ४. दिनरात्र्यार्धे for (दिनरात्र्येर्धे) १. नस्तमयार्क्कात्स for (नस्तमयार्कात्स)

(ङ) ४. 'लुप्त' for (दिनरात्र्येर्धे) ५. दलंविना for (दलादविना)
६. +दिनरात्र्यर्धे+१. ऽनस्तमयार्कान् for (नस्तमयार्कात्)

आय [1]निवक्त्योनां [3]प्रश्नानामुत्तरं चतु:षष्टिः[5] ।
आया[2]स्त्रिप्रश्नो[4]क्ताशेषप्रश्नोत्तरोक्तिरतः ।। १८ ।।
[5]विषुवच्छाया [1]गुणिता स्वाहोरा[2]त्र्यार्द्धं भाजिता [4]त्रिज्या ।
क्रान्तिद्वादशगुणिता फलचापकला[3]श्रुभिः सहितैः ।। १९ ।।
स्वचरप्राणै[3]र्दिनगतशेषैः सममंडले रवि[2]र्भवति ।
फल चापा[1]शू[2]न्यभिस्तिथि घटिकाभि [2]नताभिर्वा ।। २० ।।
उदयसममंडला[5]न्तरं घटिकाज्या[1]लंब[2]काहतं गुणयेत् ।
[3]अक्षज्यया [4]हृतां तत त्क्रांन्त्या व्यासार्द्धसंगुणया ।। २१ ।।

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१८. (घ) १. आर्यनिवकोक्तानां (ग) (ङ) for (आयनिवक्त्योनां)
२. आर्यास्त्रि (ग) (च) for (आयास्त्रि)
(ग) ३. प्रस्नाना for (प्रश्नाना) ४. प्रस्नोक्ताः for (प्रश्नोक्ता)
(च) १. आर्यनिवक्त्यानां for (आयनिवक्त्योनां)
(ङ) ५. षष्टया for (षष्टिः) २. आर्याणां for (आयास्त्रि)
४. प्रश्नोक्त्या for (प्रश्नोक्ता)

१९. (घ) १. गुणित (ग) गुणित (ङ) for (गुणिता)
२. रात्रार्धं (ग) (ङ)for(रात्र्यार्द्धं)
(ग) ४. त्रिज्याः for (त्रिज्या)
(च) १. गुणित for (गुणिता) २. रात्रार्द्धं for (रात्र्यार्द्धं)
३. कलासुभिः for (कलाश्रुभिः)
(ङ) ५. विषुवच्छाया for (विषुवछाया)

२०. (घ) १. चापाशूनाभि (ग) चापास्तनुभि for (चापाशून्यभि)
२. न्न्रंतानिर्वाः (ग) नंताभिर्वा for (नताभि)
(च) ३. द्विन for (दिन) १. शून्याभि for (शून्यभिः)
२. न्नताभिर्वाः for (नताभिर्वा)
(ङ) १. चापन्यूनाभि for (चापाशून्यभि) २. नंताभि for (नताभि)

२१. (घ) १. ज्यां (ङ) for (ज्या) २. लंबकाहता (ङ) (ग) लंबकाहलांfor (लंबकाहतं)
३. अज्यया (ग) अक्षया for (अक्षज्यया)
४. हृत्यांतक्रान्त्या (ग) हृतांत्यक्रान्त्या for (हृतां ततत्क्रान्त्या)
(ग) ५. मडलांतरघटिकाज्यां for (मंडलान्तरं घटिकाज्या)
(च) २. हतां for (हतं) ४. हृत्यांतक्रांत्या for (हृतांततत्क्रान्त्या)
(ङ) ४. हृताऽन्त्यक्रान्त्या for (हृतां ततत्क्रांन्त्या)

लब्धधनु[5]रवि[1]रजाक्ष [3]कर्कटकादौ [2]विशोद्ध चक्रार्द्धात् ।
[6]तज्या तदुदय सममंडलांतरा [4]क्षुज्ययाभक्ता ॥ २२ ॥
[2]प्रश्न सममण्डला सुक्रमज्यया संगुणा [4]सकृत्सूर्यः ।
[3]प्रश्न घटिकाभिरेवं [1]गतघटिकाभि[5]र्भवत्यहः ॥ २३ ॥
त्रिज्या[4]दिनार्द्धसममंडलांतरा [1]सुज्यायाः कृतिविशेषः ।
[5]स्वविषय[2]विषुवच्छाया वर्गेण गुणो द्विधा [3]प्रथमाः ॥ २४ ॥
व्यासार्द्ध[1]वर्गभक्तौ लब्धं [2]ध्वादशकवर्ग [3]संयुक्तम् ।
छेदो द्वितीयराशे [4]लब्धं पदं क्रान्ति[5]रर्कातः ॥ २५ ॥

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२२. (घ) १. रजादौ (ग) (च) for (रजाक्षै) २. विशोध्य (ग) (च) for (विशोद्ध)
(च) ३. कक्कर्ट for (कर्कट) ४. सुज्यया for (क्षुज्यया)
(ङ) ५. रिनो for (रवि) १. ऽजादौ for (रजाक्षै)
३. कर्क्याकौ यदि for (कर्कटकादौ) २. विशोध्य for (विशोद्ध)
६. तज्ज्या for (तज्या)

२३. (घ) १. गत शेषोभिर्भवत्यह्नः (ग) गतशेषाभिर्भवत्यह्नः for (गतघटिकाभिर्भवत्यहः)
(ग) २. प्रस्न for (प्रश्न) ३. प्रस्न for (प्रश्न)
(च) ४. सकृसूर्यः for (सकृत्सूर्यं) ४. गतशेषाभि (ङ) for (गतघटिकाभि)
५. र्भवत्यह्नः (ङ) for (र्भवत्यहः)
(ङ) ४. ऽसकृत् सूर्यः for (सकृत्सूर्यः)

२४. (घ) १. सुज्ययोः (ग) (ग) (ङ) for (सुज्यायाः)
२. विषुछाया (ग) (च) for (विषुवछाया)
३. प्रथमः (ग) (च) (ङ) for (प्रथमाः)
(ग) ४. दिनासम for (दिनार्द्धसम) ५. स्वविष for (स्वविषय)
(च) २: विषुवच्छायावर्गेण for (विषुवछायावर्गेण)

२५. (घ) १. वर्ग्र for (वर्ग) (ग) वर्ग्र भक्तो for (वर्गभक्तौ)
२. द्वादश (ग) for (ध्वादश) ३. संयुक्ताम् for (संयुक्तम्)
४. र्लब्धपदं (ग) (च) (ङ) for (लब्धंपदं)
(च) ५. रक्कातः for (रर्कातः)
(ङ) १. व्यासार्ध वर्गभक्तो for (व्यासार्द्धवर्ग भक्तौ)
२. द्वादशज for (ध्वादशक) ४. रर्कोऽतः for (रर्कातः)

सममण्डल शंकुगुणाक्षज्या[3] जीनभागजीवया[1] भक्ता[2] ।
फलधनुरर्को[4]जादौ कर्क्यादौ प्रोह्य चक्रार्द्धात् ॥ २६ ॥
द्वादशगुणिताक्षज्या[2] विषुवच्छायो[3] गुणावलंबज्या ।
सममंडल कर्कादौ[1] क्रान्तिज्ये भास्करः प्राग्वत् ॥ २७ ॥
परमापक्रमजीवा तत्कालिक[1]सूर्यबाहुसंगुणिता ।
सममंडलशंकुह्लता[2]क्षज्या[3] तच्चापमक्षांशाः ॥ २८ ॥
लंकोदय[4]चरदलवद्रविलग्नाभ्यां पृथक् पृथक् प्राणाः[1] ।
कृत्वा तदंतरैक्यं मृगकर्क्यादिषु[2] पृथक्[3] लिप्ताः ॥ २९ ॥

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२६. (घ) १. दिन (ग) जिन for (जीन) २. भक्ताः (ग) for (भक्ता)
(ग) ३. क्षय्या for (क्षज्या)
(च) ३. जिनभाग for (जीनभाग) ४. धनुरर्क्को for (धनुरर्को)
(ङ) ३. ऽक्षज्या for (क्षज्या) १. जिन for (जीन)
४. रर्कोऽजादौ for (रर्कोजादौ)

२७. (घ) १. कर्णाकृते (ग) कर्णाहृते (ङ) for (कर्कादौ)
(ग) २. क्षय्या for (क्षज्या)
३. विषुवच्छाया for (विषुवच्छायो (च) for (विषुवच्छायो)
(च) १. कर्णाहृते for (कर्कादौ)
(ङ) २. ऽक्षज्या for (क्षज्या) ३. विषुवच्छाया for (विषुवच्छायो)

२८. (घ) १. तात्कालिक for (तत्कालिक)
(ग) २. हृता for (ह्लता) ३. क्षय्या for (क्षज्या)
(ङ) ३. ऽक्षज्या for (क्षज्या)

२९. (घ) १. प्राणान् (ग) (च) for (प्राणाः)
२. मृगकक्यादिषु (ग) मृगकर्कादिषु for (मृगकर्क्यादिषु)
३. पृथग्लिप्ताः (ग) (च) (ङ) for (पृथक्लिप्ताः)
(ग) ४. लंकोदचरदलद्रवि for (लंकोदयचरदलवद्रवि)
(च) २. मृगकर्क्क्यादिषु for (मृगकर्क्यादिषु)
(ङ) १. प्राणान् for (प्राणाः)

मेषादिषु कर्कादिषु[1] विशोध्य[6] भार्द्धा[2] तुलादिषु[6] सभार्द्धा[3] ।
मकरादिषु संशोध्याश्चक्ररवि[4] भुक्ता[5] लिप्ता वा ॥ ३० ॥
लग्नकाला[1]यद्यूना[2] सचकालिप्ता[3] विना[5] स्वराश्यूदयैः[4] ।
एवं स्फुटाभवंत्यर्क[6] लग्नयोरंतर[7]प्राणाः ॥ ३१ ॥
अष्टयमा[1]श्रुत्य[2] गुणा दिगिषु कालोना[3] रदाः सतिथिलिप्ताः ।
स्वचरार्द्धांशैरूना[4] विपरीता[6] संयुता व्यस्तै[5] ॥ ३२ ॥

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३०. (घ) १. कक्यादिषु (ग) कक्यादिषु (ङ) for (कर्कादिषु)
२. भार्द्धात् (ग) for (भार्द्धा) ३. सभार्द्धाः (ग) for (सभार्द्धा)
४. चक्राद्रवि (ग) (च) (ङ) for (चक्ररवि)
५. भुक्तलिप्तोनाः (ङ) (ग) भुक्तलिप्तोना for (भुक्तालिप्तावा)

(च) १. कक्वर्यादिषु for (कर्कादिषु) ६. तुलादीषु for (तुलादिषु)
३. "सभार्द्धा" लुप्त ५. भुक्तलिप्तोनाः for (भुक्तालिप्तावा)

(ङ) ६. शोध्या for (विशोध्य)

३१. (घ) १. लग्नकला (ग) (च) (ङ)for (लग्नकाला)
२. यद्यनाः (ग) (च) (ङ)for (यद्यूना)
३. सचक्रलिप्ता (ग) (ङ) for (सचकालिप्ता)
४. राश्युदयैः (ग) रास्युदयैः for (स्वराश्यूदयैः)

(ग) ५. दिना for (विना)

(च) ३. सचक्रलिप्ताः for (सचकालिप्ता) ४. स्वराश्युदयैः for (स्वराश्यूदयैः)
६. भवंत्यक्र्क for (भवंत्यर्क)

(ङ) ४. स्वराश्युदयैः for (त्वराश्यूदयैः) ७. रंतते for (रंतर)

३२. (घ) १. यमाः (ग) (च) (ङ) for (यमा)
२. शून्य (ग) (च) (ङ) for (श्रुत्यगुणा)
३. कलोना (ग) (च) (ङ) for (कालोना) ४. रूनाः (च) for (रूना)
५. व्यस्तैः (ग) (च) (ङ) for (व्यस्तै)

(ग) ६. विपरीताः (ङ) for (विपरीता)
(च) ६. विपरिताः for (विपरीता)

व्यस्ता[1] चा जादीनां[2] कलांशलग्नमिष्टघटिकांशैः ।
लग्ना[3] घटिकाः कालांशे[4] विनैवं[5] स्वराश्यूदयैः[6] ।। ३३ ।।
इष्टार्क[4] चरार्द्धं[2] ज्या[1] क्षयवृद्धिज्याद्यु[5]रात्रिदलगुणिता[3] ।
व्यासार्द्धेन विभक्ता क्षितिजा द्वादशगुणा भक्ता ।। ३४ ।।
क्रांत्याविषुवच्छाया क्षितिजेष्टं क्रान्तिवर्ग[1]योगं पदम् ।
अग्रे[2] क्षितिजापक्रमजीवे[3] त्रिज्या गुणोभक्ता[4] ।। ३५ ।।
अर्का[6]ग्रयाक्षकलंबक[4]जीवे दिनकृत[1]चरासुविज्ञाने ।
अर्कज्ञाने[2] ज्ञाने[5] विषुवच्छाया चराभूनाम्[3] ।। ३६ ।।

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३३. (घ) १. व्यस्तश्चाजादीनां (ग) (च) (ङ) for (व्यस्ताचाजादीनां)
२. कालाँशा (ग) कालांशो for (कलाँश)
३. लग्नाद्धटिकाः (ग) (च) (ङ) for (लग्नाघटिकाः)
४. कालांशकै (ग) (च) (ङ) for (कालांशै)
५. विनैवं (ग) (च) (ङ) for (विनैवं)
६. स्वराश्युदयैः (ग) (च) (ङ) for (स्वराश्यूदयैः)
(च) २. कालांश for (कलांश) (ङ) २. काजांशैर्लग्न for (कलांशलग्न)

३४. (घ) १. क्षयं for (क्षय)
(ग) २. चरार्द्धज्या (ङ) for चरार्द्धंज्या) ३. गुणिताः for (गुणिता)
(च) ४. इष्टार्क्क for (इष्टार्क) २. ह्याक्षय for (ज्याक्षय)
(ङ) ५. द्यु रात्रदल for (द्यु रात्रिदल)

३५. (घ) १. वर्गयोगपदम् (ग) (च) for (वर्णयोगंपदम्)
२. अग्ना (ग) अग्रा for (अग्रे) ३. जीव (ग) जीवा for (जीवे)
४. गुणेभक्ते (ग) (च) (ङ) for (गुणोभक्ता)
(च) २. अग्रक्षिति for (अग्रे क्षिति) ३. जीवत्रीज्या for (जीवेत्रिज्या)
(ङ) १. वर्गयोगपदम् for (वर्णयौगंपदम्) २. अग्रा for (अग्रे)

३६. (घ) १. कृच्चरा for (कृतचरा) (ग) दिनकृच्चरासुविज्ञाते for (दिनकृतचरासुविज्ञाते)
२. अर्का (ग) for (अर्के) ३. चरासूनाम् (ग) (ङ) for (चराभूनाम्)
४. 'क' यहां 'क' लुप्त है (च) (ङ) ५. ज्ञाते ज्ञाते for (ज्ञाने ज्ञाने)
(च) ६. अर्क्काग्र for (अर्काग्र) ४. लंबक for (कलंबक)
१. दीनकृच्चरा for (दिनकृतचरा) २. अर्क्काज्ञाने for (अर्कज्ञाने)
३. चरासूनां for (चराभूनाम्)
(ङ) ६. अर्काग्रयाऽक्ष for (अर्काग्रयाक्ष) १. कृच्चरासु for (कृतचरासु)
२. अर्काज्ञाने for (अर्कज्ञाने) ७. विषुवच्छाया for (विषुवछाया)

अष्टचरार्द्धयस्य[1] ज्या क्षयवृद्धि ज्यातदर्कवधकृत्या[2] ।
त्रिज्याविषवच्छाया[5] वधवर्गो[3] युतवधच्छेदः[4] ॥ ३७ ॥
व्यासार्द्धकृते[1] मूलं क्रांतिज्यावासदलगुणा[2] भक्ता ।
जीनभागजीवया[3] लब्ध[6]चापमर्क[4]पादैः[5] प्राग्वत् ॥ ३८ ॥
विषुवच्छाया[2] भक्ता स्वचरार्द्धज्येष्टयात्यया[1] भक्ता गुणिता ।
लब्धस्य चापमिष्टं[3] छायायाश्चरदलप्राणाः ॥ ३९ ॥
स्वचरार्द्धज्या[1]भक्ता विषुवच्छायेष्ट[4] चरदल[2] श्रुनाम् ।
गुणिताज्येष्ट[3] चरदल विषुवच्छाया[4] फलं भवति ॥ ४० ॥

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३७. (घ) १. चरार्धस्य (ग) इष्टचरार्द्धस्य for (अष्टचरार्द्धयस्य)
२. कृत्याः (ग) क्रत्या for (कृत्या) ३. ववर्गो for (वधवर्गो)
४. हृताछदः (घ) हृतछेदः for (युतवधछेदः)
(ग) १. अष्टचरार्द्धस्य ज्या for (अष्टचरार्द्धयस्य ज्या) २. क्रत्या for (कृत्या)
४. हृतछेदः for (वधछेदः)
(ङ) १. इष्टचरार्धस्य for (अष्टचरार्द्धयस्य) ५. विषुवच्छाया for (विषूवछाया)
४. युतहृतश्छेदः for (युतवधछेदः)
३८. (घ) १. कृतेर्मूलं (ग्र) भुक्तेर्मूलं for (क्रतेमूलं) २. व्यास (ग) (ङ) for (वास)
३. जिन (ग) (च) (ङ) for (जीन) ४. मर्कः for (मर्क)
५. पदैः (ग) (ङ) for (पादैः)
(ग) ६. लब्धं for (लब्ध)
(च) १. कृते for (क्रते) ४. मर्क्कः for (मर्क)
(ङ) १. कृतेर्मूलं for (क्रतेमूलं)
३९. (घ) १. व्यया गुणिता (ग) न्यया गुणिता for (त्यया भक्ता गुणिता)
(च) १. ज्येष्टयान्यया गुणिता for (ज्येष्टयात्ययाभक्ता गुणिता)
(ङ) २. विषुवच्छाया for (विषुवछाया) १. ऽन्यया for (त्यया)
३. मिष्टच्छायाया for (मिष्टछायाया)
४०. (घ) १. चरार्द्धज्या (ग) व्यचरार्द्धज्या for (चरार्द्धज्या)
२. चरदलासूनाँम् (ग) (ङ) for (चरदलश्नुनाम्)
(ग) ३. ज्ययैष्ट for ज्ययेष्ट)
(च) २. चरदलामूनां for (चरदलश्नुनाम्) ३. चेष्ट for (ज्येष्ट)
(ङ) १. चरार्धज्या for (चरार्द्धज्या) ३. ज्ययेष्ट for (ज्येष्ट)
४. विषुवच्छायेष्ट for (विषुवछायेष्ट)
५. विषुवच्छाया for (विषुवछाया)

मध्यम[1]च्छायाग्रमुदक् शंकुतला[2]दक्ष[3]नत[4]भागः ।
दक्षिणतो[6] यदि सौम्याः स्वाक्षांशा[5] सर्वदा याम्याः[7] ॥ ४१ ॥
द्यु दलनतोक्षांशानामेक[1] दिशानामंतरं[6] युति[5]भेंदे[2] ।
क्रांत्यंशाः प्रागदिनः[3] क्रांत्यंशोरेव[4] मक्षांशाः ॥ ४२ ॥
उदये[1] ज्येष्ठापक्रम[4] जीवा कृत्यंतरात्पदं क्षितिजा[2] ।
व्यासार्द्ध[5] गुणा क्षितिजा भक्तोदयजिवया[3] कक्षः[4] ॥ ४३ ॥

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४१. (घ) १. मध्यछाया (ग) for (मध्यमछाया)
२. तलाद्दक्षिणे (ग) तलाद्दक्षिणोनतभागाः for (तलाद्दक्षिणा नता भागाः)
३. नता (ङ) for (नता) ४. भागाः (ङ) (भागः)
५. स्वाक्षांशाः (च) (ङ) for (स्वाक्षांशा)
(ग) ६. दक्षणतो for (दक्षिणतो) ७. याम्या for (याम्याः)
(च) १. मध्यछायाग्रमुदक् for (मध्यमछायाग्रमुदक्)
६. द्दक्षिणतो for (दक्षिणतो)
(ङ) १. मध्यच्छाया for (मध्यमछाया) २. द्दक्षिणा for (दक्ष)

४२. (घ) १. नतांक्षा शानामेक (ग) नतः क्षांशानामेक for (नतोक्षांशानामेक)
२. भेदो (ग) भेदै for (भेंदे)
३. प्राग्वदिनः (ग) प्राग्वदितः for (प्रागदिनः)
४. क्रांत्यंशैरेव (ग) (च) (ङ) for (क्रान्त्यंशोरेव)
(ग) ५. 'युति' लुप्त है
"क्रांत्यंशाः प्राग्वदितः" दो बार लिखा गया है।
(च) १. द्यु दलनताक्षांशानामेक for (द्यु दलनतोक्षांशानामेक)
३. प्राग्वदिनः for (प्रागदिनः)
(ङ) १. नताक्षांशानामेक for (नतोक्षांशानामेक)
६. दिशामन्तरं for (दिशानामंतरं) ३. प्राग्वदनः for (प्रागदिनः)

४३. (घ) १. उदय (ङ) for (उदये) २. क्षितिजाल्पा for (क्षितिजा)
३. जीवयाक्षज्या (च) for (जिवयाकक्षः)
(ग) 'म' लुप्त
४. पक्षज्यात् शेषाः ॥४३॥ for (कक्षः)
(च) ३. जीवयाक्षज्या for (जिवयाकक्षः)
(ङ) ५. व्यासार्थ for (व्यासार्द्ध) ३. जीवयाऽक्षज्या for (जिवयाकक्षः)

उदय ज्यया[२]विभक्ता क्रांतिज्या व्यास[३]गुणालंबः[४] ।
द्वादश[१]गुणिता क्षितिजा विषुवछाया[५] हूता[१] क्रान्तिः ॥ ४४ ॥
यष्टिव्यासार्द्धंग्रा[१]प्राच्यपरा भास्करांतरां[२]शज्या ।
द्विगुणमुदया[३] सूत्रं तत्त्रिज्या कृति[४]विशेषपदम् ॥ ४५ ॥
द्यु[३]दले शंकु[४] न तज्ये[७] प्राच्यपराया यदि स्थितः शंकुः ।
उदगूना[५] दक्षिणतः[१] स्तदंतरे[२]णाधिकार्काग्रा[६] ॥ ४६ ॥
उत्तरगोले[१] नं[४] तदं[३] याम्य गोलगे[५] सूर्ये ।
शंकुतल[२] शंकु हूतं[३] विषुवछाया द्विषट्क गुणम् ॥ ४७ ॥

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४४. (घ) १. हृता (ग) (च) for (हूता)
(ग) २. ज्याया for (ज्यया) ३. +दल+ (ङ) (च)
४. लब्धाम् for (लम्बः)
(ङ) ५. विषुवच्छाया for (विषुवछाया)

४५. (घ) १. ऽग्रा (च) for (ग्रा)
(ग) २. 'तरां' पद लुप्त है
३. मुदयास्तसूत्रं (ङ) for (मुदयासूत्रम्)
४. क्रांति for (कृति)
(च) २. ज्याः for (ज्या)
(ङ) १. व्यासार्धेऽग्रा for (व्यासार्द्धंग्रा)

४६. (घ) १. दक्षिणत (ग) for (दक्षिणतः)
२. ऽधिका for (धिका)
(ग) ३. द्यूदले for (द्युदले) ४. शंकुतज्ये for (शंकुनतज्ये)
५. उदगुना for (उदगूना) ६. काकाग्रा for (कार्काग्रा)
(च) ७. तछे for (तज्ये) १. दक्षिणांत for (दक्षिणतः)
६. ऽधिकार्क्काग्रा for (धिकार्काग्रा)
(ङ) १. दक्षिणत for (दक्षिणतः)

४७. (घ) १. गोलेर्ग्रो (ग) उत्तगोलेग्रो for (उत्तर गोले)
२. तलं (ग) (ङ) for (तल)
३. हृतं (ग) (ङ) (च) for (हूतं)
(ग) ४. मंतदंतरं for (नं तदंतरं) ५. गोले for (गोलगे)
(च) १. गोलग्रोनं for (गोलेनं) ३. तदंतरं for (तदं)
७. विषुवच्छाया for (विषुवछाया)

शंकुतलशंकुगुणिते त्रिज्ये तद्वर्गयुतिपदविभक्ते[1] ।
अक्षावलंबज्ये[2] द्युदलस्थेऽर्कन्यदा[3] द्युदलात्[4] ॥ ४८ ॥
छायावृतेऽर्कग्रा[1] कर्णगुणा व्यासदल हृताकाग्रा[2] ।
प्राच्यपरा शंक्वंतर[3]मुत्तरयाम्यं तदून[4] युता[5] ॥ ४९ ॥
उत्तर गोले याम्ये विषुवच्छाया[3]ग्रयांतरं[4] हीनम् ।
एवं विषुवच्छाया युक्ति[1]विहीनांतरेणाग्रा[2] ॥ ५० ॥
बाहु[5]क्रांतिः कोटिः क्षितिजा[2]तद्वर्गयुतिपदं कर्णः ।
अग्रोदयास्त[3] सूत्राद्दक्षिणतो[4] द्रश्य[1] शंकु तलम् ॥ ५१ ॥

४८. (घ) १. तर्द्वर्ग for (तद्वर्ग)
२. अक्षावलंबकज्ये (ग) अक्षावलंबकज्ये (ङ) for (अक्षावलंबज्ये)
३. ऽर्केऽन्यदा (ग) स्छेऽर्केन्यद for (ऽर्कन्यदा)
(ग) ४. द्यूदलात् for (द्युदलात्)
(च) १. तर्द्वर्ग for (तद्वर्ग) २. अक्षावलंबकद्ये for (अक्षावलंबज्ये)
३. ऽर्क्केऽन्यदा for (ऽर्कदान्यदा)
(ङ) ३. ऽर्क्केऽन्यदा for (ऽर्कन्यदा)
४९. (घ) १. वृत्तऽर्काग्रा (ग) (ङ) for (वृतेऽर्कग्रा)
२. हृता for (ह्लता)
(ग) ३. शंकुतर for (शंक्वन्तर) ४. तदूनं for (तदून)
५. युतम् for (युता)
(च) १. छयावृत्तेऽर्क्काग्राकर्णा for (छायावृत्तेऽर्कग्राकर्णा)
२. हृताक्कीग्रा for (हृताकाग्रा) ४. तदूना for (तदून)
(ङ) २. हृताऽर्काग्रा for (हृताकाग्रा)
५०. (घ) १. युक्त (ग) (च) (ङ) for (युक्ति)
(ग) २. विहिनां वा रणाग्रा (विहीनांतरेणाग्रा)
(ङ) ३. विषुवच्छाया for (विषुवछाया) ४. ऽग्रयान्तरं for (ग्रयांतरं)
५. विषुवच्छाया for (विषुवछाया)
२. विहीनाऽन्तरेणा for (विहीनांतरेणाग्रा)
५१. (घ) १. दृश्य (ग) for (द्रश्य)
(ग) २. क्षितिजां for (क्षितिजा) ३. अग्रोदयास्त्र for (अग्रोदयास्त)
४. दक्षणतो for (दक्षिणतो)
१. दृश्य (ङ) for (द्रश्य)
(ङ) ५. बाहुः for (बाहु)

त्रिज्याक्षयवृद्धिद्यै[१]कांतर मुदगितरयोर्दिनार्द्धांत्या[२]।
व्यासार्द्धचरार्द्धं[३] ज्यांतर[४] संयोगोर्द्धं[५]रात्रांत्या ॥ ५२ ॥
उक्रम[१]जीवा[२] चापं क्रमजीवाचापसहितमधिकं[३] यत्[५]।
दिनरात्र्यर्द्धं प्राणाः पृथग्दिना[४] चरदलप्राणैः ॥ ५३ ॥
दिवसार्द्धो[३]त्क्रमजीवाधिकक्रमज्या[४]धिकादिनार्द्धंत्या[१]।
व्यासार्द्धं दिनार्द्धांत्यांतर[२] चरज्याक्षय[५]जीवातः ॥ ५४ ॥

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५२. (घ) १. द्यैक्यांतर (ग) ज्यैक्यांतर for (द्यैकांतर)
(ग) २. दिनार्द्धाद्वा for (दिनार्द्धांत्या) ३. दिनार्द्ध for (चरार्द्ध)
४. ज्यांतरं for (ज्यांतर) ५. संयोगेर्द्ध for (संयोगोर्द्ध)
(च) २. द्दिनार्द्धांत्या for (दिनार्द्धांत्या)
(ङ) १. ज्यैक्यान्तर for (द्यैकान्तर) २. दिनार्धान्त्या for (दिनार्द्धांत्या)
३. व्यासार्ध चरार्ध for (व्यासार्द्ध चरार्द्ध)
५. संयोगेऽर्धरात्र्यन्त्या for (संयोगोर्द्ध रात्रांत्या)

५३ (घ) १. उत्क्रम (ग) (च) for (उक्रम)
(ग) २. तीवा for (जीवा) ३. मधीकं चेत् for (मधिकं यत्)
४. विमा for (दिना)
(ङ) १. उत्क्रम for (उक्रम) ५. चेत् for (यत्)
४. पृथग् विना for (पृथग्दिना)

५४. (घ) १. नार्द्धांत्या (ग) (च) for (नार्द्धंत्या)
२. त्यांतरं (ग) (च) for (त्यातर)
(ग) ३. दिवासार्कोत्क्रम for (दिवसार्द्धोत्क्रम) ४. ज्यया for (ज्या)
५. 'य' लुप्त है (ङ)
(च) ५. चरद्याक्षजीवातः for (चरज्याक्षयजीवातः)
(ङ) ३. दिवसार्धोत्क्रम for (दिवसार्द्धोत्क्रम) ४. ज्याऽधिका for (ज्याधिका)
१. दिनार्धान्त्या for (दिनार्द्धंत्या)
२. व्यासार्ध दिनार्धार्द्धन्त्यान्तरं for (व्यासार्द्ध दिनार्द्धांत्यातर)
५. ऽक्षजीवाऽतः for (क्षयजीवातः)

स्वाहोरात्रार्द्धसम[1] यत्राक्षज्याबलंबक:[2] ।
क्रान्त्या[3] ह्येषा[4] दिगम्यता वद्यावत्[5] कर्क्यादिगस्य[6] खे: ॥ ५५ ॥
नास्तमयस्तत्र[3] तुला मकरादिस्थस्य[4] नोदयोर्कस्य[2,1] ।
तन्मध्यांतरलिप्ता मध्यमभुक्त्या हृता[2] दिवसा: ॥ ५६ ॥
कोणछाया[8] क्रतिदल[7] यद[1]विषुवछायाया[5] रूदानृतबलं[2] प्राच्य परयो:[3] ।
यद्यैक्यंतरं[4] याम्यदिक्स्थं[6] चेत् ॥ ५७ ॥

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५५. (घ) १. समा (ग) for (सम)
२. ज्यावलंबक: क्रान्त्या for (ज्याबलंबक: क्रान्त्या)
३. यह पद 'पहली पंक्ति के अन्त में है ।
४. मेषादिगस्य (ग) for (ह्येषा दिगम्यता)
५. तावद्यावत् for (वद्यावत्) ६. कर्कादिगस्य for (कर्क्यादिगस्य)
(च) १. समा यात्रा for (सम यत्रा) ४. मेषादिगस्य for (ह्येषादिगम्य)
६. कक्यांदिगस्य for (कर्क्यादिगस्य)
(ङ) १. रात्रार्धसमा for (रात्रार्द्ध सम)
३. 'क्रान्या' यह शब्द पहली पंक्ति का अन्तिम है ।
४. ५. मेषादिगस्य तावद्यावत् for (ह्येषा दिगम्यता वद्यावत्)

५६. (च) १. नोदयोऽर्कस्य (ग) नोदयेऽर्कस्य for (नोदयोर्कस्य)
२. हृता (ग) (ङ) for (हृता)
(ग) ३. सूत्रतुला for (स्तत्र तुला) ४. छस्य for (स्थस्य)
(च) १. नोदयोऽर्क्कस्य for (नोदयोर्कस्य) २. हृता for (हृता)
(ङ) १. नोदयोऽर्कस्य for (नोदयोर्कस्य)

५७. (घ) १. पद (ग) (च) (ङ)for (यद) २. रुदग्नृतलं (ग) (ङ) for (रुदानृतल)
वि० श्लोक की पहली पंक्ति समाप्त ।
३. 'प्राच्य परयो:' दूसरी पक्ति के आरंभिक पद हैं (ग)
४. यद्यैक्यमंतरं (ग) (च) (ङ) for (यद्यैक्यंतरं)
(ग) ५. छाययो for (छायाया) ३. प्राच्य पराया (ङ) for (प्राच्यपरयो:)
वि० दूसरी पंक्ति का आरम्भ ।
६. स्छ for (स्थं)
(च) ७. कृतिदल (ङ) for (क्रतिदल) २. रुदग्नृतबलं for (रुदानृतबलं)
(ङ) ८. कोणच्छाया for (कोणछाया) ५. विषुवच्छाययो for (विषुवछायाया)

कोण[2]छायाकर्णेन भक्तमवलंबकेन संगुणितम् ।
इष्टापक्रमजीवा त्रिप्रश्नोक्त्या स्फुटोर्कोंतः[1] ।। ५८ ।।
मध्यम[3]गति स्फुटगति[4] त्रिप्रश्नात्[6] सोत्तरान् विजानाति यः[1] ।
स भवत्याचार्यो ब्रह्मोक्ता[5] ज्ञानतंत्रज्ञाः[2] ।। ५९ ।।
अध्यायः पंचदशस्त्रि[5]प्रश्नस्योत्तरं यदीह[1] नोक्तम् ।
[6]आर्याषष्टचोक्तं तद्गोला[2]दुत्प्रेक्ष्य बुद्धिमता[3] ।। ६० ।।

[4]इतिब्रह्म गुप्ते त्रिप्रश्नाध्यायः

पंचदश अध्यायः समाप्तः

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५८. (ङ) २. कोणच्छाया for (कोणछाया) १. ऽर्कोऽतः for (र्कोंतः)

५९ (घ) १. 'यः' दूसरी पंक्ति का पहला पद है।
२. तंत्रज्ञः (च) for (तंत्रज्ञाः)

(ग) ३. मध्यगतिः for (मध्यमगति)
४. स्पष्टगतिः for (स्फुटगति) १. 'यः' लुप्त है
५. वै ब्रह्मोक्तानान्य तंत्रज्ञा for (ब्रह्मोक्ताज्ञानतंत्रज्ञाः)

(ङ) ३. मध्यगति for (मध्यमगति) ४. स्पष्टगति for स्फुटगति)
६. त्रिप्रश्नान् for (त्रिप्रश्नात्) १. 'यः' लुप्त।
५. ब्रह्मोक्तान् for (ब्रह्मोक्ता) २. योऽन्यतंत्रज्ञः for (ज्ञानतंत्रज्ञाः)

६०. (घ) १. यदिह (ग) (ङ) for (यदीह) २. दुप्रेक्ष्य for (दुत्प्रेक्ष्य)
३. बुद्धिमताः for (बुद्धिमता)
वि०—४. 'इति' से आरंभ कर 'समाप्त' तक मूल में लुप्त है।

(ग) ५. त्रि for (स्त्रि) ६. तच्चार्याषष्टयो यं for (आर्याषष्टचोक्तं)
४. इति ब्रह्मसिद्धांते त्रिप्रश्नोत्तर पंचदशोध्यायः for (इत्ति ब्रह्मगुप्ते त्रिप्रश्ना-ध्यायः)

(च) १. यदिह for (यदीह)
४. 'इति' से 'समाप्तः' तक समस्त लुप्त

(ङ) १. तच्चार्याषष्टयाऽयं for (आर्याषष्टचोक्तं)
२. गोलादुत्प्रेक्ष्य for (तद्गोलादुत्प्रेक्ष्य)

अथ ग्रहणोत्तराध्यायः

षोडशः

ग्रहणग्रहसंयोगग्रहः[1] क्षीयोगेषु[3] सर्वतन्त्र[4]विदाम् ।
आचार्य[5]छेद्यक[6] विद्यतस्ततः[7] छेदकं[2] वक्षे[8] ॥ १ ॥
दुर्जनकृतघ्नशत्रु प्रतिकंचुक करि[1]पतितमुर्खेभ्यः[2] ।
छेदक[3]मदेयभ्यो[4]ददतः[6] सुकृतायुषोर्नशिः[5] ॥ २ ॥
उषिताय दीर्घकाल[1]शिष्याय गुणान्विताय[4] भक्ताय ।
आत्रे[5] वास्तुह[2] देवा सुताय वा छेदकं[3] देयम् ॥ ३ ॥

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१. (घ) १. ग्रह (ङ) (ग) for (ग्रहः) २. छेद्यकं (च) (ङ) for (छेदकं)

(ग) ३. क्षतंत्रेषु for (क्षीयोगेषु) ४. 'तंत्र' लुप्त है, (ङ)
५. आचार्यः for (आचार्य) ६. छेदक for (छेद्यक)
७. तत् for (ततः) ८. वक्ष्ये (ङ) for (वक्षे)

(ङ) ३. क्षतंत्रेषु for (क्षीयोगेषु) ५. आचार्यश् for (आचार्य)
७. ततश् for (ततः)

२. (घ) १. कारि (ग) (ङ) for (करि) २. मूर्षेभ्यः (ग) for (मुर्खेभ्यः)
३. छेद्यक (ग) (ग) (ङ) for (छेदक) ४. यमेभ्यो (ग) (ङ) for (यम्यो)
५. नशि (ग) नाशः for (नशिः)

(ग) ६. दहतः for (ददतः)

(च) १. कारिपतित for (करिपतित) २. मूर्षेभ्यः for (मुर्खेभ्यः)
४. मदेयमेभ्यो for (मदेयभ्यो)

(ङ) २. मूर्खेभ्यः for (मुर्खेभ्यः)

३. (घ) १. दीर्घकालं (ग) (च) (ङ) for (दीर्घकाल)
२. सुहृदेवा (ग) for (स्तुहदे) ३. छेद्यकम् (च) (ङ) for (छेदकं)

(ग) ४. गुणाधिकाय (ङ) for (गुणान्विताय)

(च) २. वासुहृदेवा for (वास्तुहदेवा)

(ङ) ५. पात्रे for (आत्रे) २. सुहृदे वा for (स्तुहदे वा)

विषुवदयमंडलदिशो[1] वलनज्याभि ग्रहास्त्रिग्रहवृत्ते[2] ।
संपर्क्क[5] ग्राह्यावायो[3] वेत्ति छेदकज्ञः[4] सः ॥ ४ ॥
संपर्कमण्डले[4] यः प्रग्रहमोक्षो[2]पृथक्[3] स्वविक्षेपात् ।
मध्यान्मध्यग्रासं परिलिखित[1] छेदकज्ञः[5] सः ॥ ५ ॥
परिलितीष्ट[1]ग्रासं तत्कालिक[5] बाहुकोटिकर्णो[2] यः ।
अथवा निमिलनोन्मीलन[3]द्वयं छेदकज्ञः[4] सः ॥ ६ ॥

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४. (घ) १. वदपमंडल (च) (ङ) for (वदयमंडल)
२. ग्रंहात्त्रि (ग) गृत्रिगृहवृत्ते for (ग्रहास्त्रिग्रहवृत्ते)

(ग) ३. ग्रास्यै for (ग्राह्य)

(च) २. ग्रंहात्त्रिगृहवृत्ते for (ग्रहास्त्रिग्रहवृत्ते) ४. छेद्यकज्ञः (ङ) for (छेदकज्ञः)

(ङ) २. भिस्त्रिगृहवृत्ते for (भिग्रहास्त्रिग्रहवृत्ते) ५. संपर्के for (संपर्क्के)
३. ग्रासं for (ग्राह्य)

५. (घ) १. परिलिषिति (ग) पिरिलिषति for (परिलिखित)

(ग) २. मोक्षे for (मोक्षो) ३. प्रथक् for (पृथक्)

(च) ४. संपर्क्क for (सम्पर्क) १. परिलिषिति for (परिलिखित)

(ङ) २. मोक्षौ for (मोक्षो) १. परिलिखति for (परिलिखित)
५. च्छेदकज्ञः for (छेदकज्ञः)

६. (घ) १. परिलिषतीष्ट (ग) परिलिषतीष्ट (च) for (परिलितीष्ट)
२. कर्णेयः (च) (ङ) for (कर्णोयः)
३. निमीलनोन्मीलन (ग) (च) for (निमिलनोन्मीलन)
४. छेद्यकज्ञः (च) (ङ) for (छेदकज्ञः)

(ग) ५. तात्कालिबाहुकोटि (ङ) for (तात्कालिकबहुकोटि)

(च) ५. तत्कालि for (तत्कालिक)

(ङ) १. परिलिखतीष्ट for (परिलितीष्ट)

ग्राह्यं परिलिखितैक्यं[१] परिलिखति[२] ग्रहादिकं[३] तत्र ।
भूमौ य[६]फलके वा पर्वर्तं[४] छद्म(द्य)कज्ञः[५] सः ।। ७ ।।
देशांतरं यथा[१] द्रक्[२] प्रग्रहणांतराद्विजानाति ।
यो[६] रेखातो[३]ध्वानं पर्वेष्ट[४]दिनात् स तत्रज्ञः[५] ।। ८ ।।
योवेति[१] राहुमार्गं तेनेष्टकाल[३]मिष्टकालाद्वा[२] ।
ग्रासं ग्रासात्कालं जानाति छेद्यकज्ञः[४] सः ।। ९ ।।
व्यास[५]प्रमाणयोगग्राह्य[१]ग्रहाकदलानि वलनाद्या[२] ।
विक्षेपा[६]श्चापरतः पभृतिखे[४] पूर्वतः[३] शशिनः ।। १० ।।

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७. (घ) १. परिलिख्यैकं (ग) परिलेख्यैक्य (ङ) for (परिलिखितैक्यं)
२. लिषति (ग) for (लिखति) ३. प्रग्रहादिकं for (ग्रहादिकं)
४. पर्वर्त्तव (ग) परिवर्त्यं (ङ) for (पर्वर्तं)
५. छेद्यकज्ञः (ग) छेदकज्ञः for (छद्यकज्ञः)
(ग) ६. यः (ङ) for (य)
(च) १. परिलिख्यैकं for (परिलिखितैक्यं) ४. पर्वर्त्त for (पर्वर्तं)
५. वछेद्यकज्ञः for (छद्यकज्ञः)
(ङ) ३. ग्रहग्रहादिकं for (ग्रहादिकं) ५. च्छेद्यकज्ञः for (छद्म(द्य)कज्ञ)

८. (घ) १. यथागत (ग) ययागत for (यथा)
२. द्दक्य्ग्रहणां (ग) for (द्रक्प्रग्रहणांतरा)
३. ऽध्वानं (ग) (च) (ङ) for (ध्वानं) ४. पर्केष्ट (च) for (पर्वेष्ट)
५. तंत्रज्ञः (ग) (ङ) for (तत्रज्ञः)
(ग) ६. योरखातो for (योरेखातो)
(च) १. यथागत for (यथा) २. द्दक्यग्रहणांतरा for (द्रक्पग्रहणांतरा)
(ङ) १. यथागत for (यथा) . २. द्दक् for (द्रक्)

९. (घ) १. वेत्ति (च) (ङ) for (वेति) २. वाः for (वा)
(ग) ३. ग्रास (ङ) for (काल) ४. छेदकज्ञः for (छद्य(द्म)कज्ञः)
(च) ३. ग्रास for (काल) २. मिष्टकलाद्वाः for मिष्टकालाद्वा)
(ङ) ४. च्छेद्यकज्ञः for (छद्य(द्म)कज्ञः)

१०. (घ) १.ग्राहक (ग) (ग) (ङ) for (ग्रहाक)
२. वलनद्या (ग) चलनज्या for (वलनाद्या) ३. रवेः (ग) (च) (ङ)(रवे)
(ग) ४. प्रभृति for (पभृति) (च) २. चलनद्यां for (वलनाद्या)
(ङ) ५. ग्रास for (व्यास) २. वलनज्या for (वलनाद्या)
६. विक्षेपश्चापरतो for (विक्षेपाश्चापरतः) ४. भवति for (प्रभृति)

दिनदलविभक्तजित्त[1]गुणदिनगतशेषाल्पजीव[3]येष्टगुणम् ।
त्रिज्यार्द्ध[4]मधिकमंगु[5]ललिप्तास्त्रिग्रह[2]ज्यया भक्तम् ।। ११ ।।
यो[5]न[1]चेत्या द्वितया द्वितया[7] दंगुललिप्ता[2] स्त्रिसंगु[8]णाष्टहतात्[2] ।
ज्याद्वि[3]तीययुक्तिभक्ता[6]त्तद्वि[7]तुष वयो[4] दरैः षड्भिः ।। १२ ।।
व्यास वलनापर्वन[1] मेकेनेष्टेना[2] चार्य[5]मितरेषाम् ।
अंगुलकलाभिरेवं शशिसित[4]परिलेख[3] सूत्राणाम् ।। १३ ।।

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११. (घ) १. जिन (ग) (च) (ङ) for (जित्त) २. स्त्रिगृह (च) for (स्त्रिग्रह)
(ग) ३. जीवयेषु (ङ) for (जीवयेष्ट) ४. तृज्यार्द्ध for (त्रिज्यार्द्ध)
५. मंडल for (मंगुल)
(ङ) ४. त्रिज्यार्ध for (त्रिज्यार्द्ध)

१२ (घ) १. चेत्पाद्वितया for (चेत्याद्वितयाद्वितया)
२. हृतात् (ग) स्त्रिहृतात् for (हृतात्)
३. द्वितय (ग) for (द्वितीय)
४. यवोदारैः (ग) यवोदरैः (ङ) for (वयोदरैः)

(ग) ५. ज्योना for (योन) १. चेज्याद्वितीयदंगुल for (चेत्या द्वितया द्वितया)
६. भक्तात् (ङ) for (भक्तात्त) ७. वितुषक for (द्वितुष)

(च) १. चेनत्याज्या for (चेत्या) ५. ज्योना for (योन)

(ङ) ५. ज्याना for (योन) ७. द्वितीय for (द्वितयाद्वितया)
८. संगणात् for (संगुणाष्ट) २. त्रिहृतात् for (हृतात्)
३. ज्याद्वितययुक्ति for (ज्याद्वितीययुक्ति)

१३. (घ) १. वलनापवर्त्तन (ग) वलनाप्रवर्त्तन for (वलनापर्वन)
२. नवार्य for (नाचार्य) (ग) न कार्यमीतरेषाम् for (नाचार्यमितरेषाम्)
३. परिलेष (ग) (च) for (परिलेख)

(च) १. पर्वत for (पर्वन) २. मेकेनेष्टेनवर्य for (मेकेनेष्टेनाचार्य)
४. नित for (सित)

(ङ) १. वलनापवर्त्तन for (वलनापर्वन) २.मेकेनेष्टेन for (मेकेनेष्टेना)
५. कार्य for (चार्य)

प्रथमे वलनज्याभिर्द्दिशो[3] द्वितीयं[1] यथादिशं भानोः ।
आद्यंतौ विक्षेपौ मध्यान्मध्योन्यथा शशिनः[2] ॥ १४ ॥
विक्षेपाग्रात्[1] ग्राह्यं परिलिष्य[3] ग्राहकप्रमाणेन[4] ।
प्रग्रहमोक्षग्रासामुपरिलेख[2] भवंत्येवम् ॥ १५ ॥
पश्चापग्रहणे[1] प्राग्मोक्षे[4] रविबिम्बं[2] मध्यतो बाहुः ।
स्ववलन सिद्धायां[5] दिशि विपरीत[6]शीतकरणमध्यात्[3] ॥ १६ ॥
भानुमते[1] बाह्वग्राद्यधा[2] दिशं कोटि[3]रन्यथा शशिनः[4] ।
रविशशिमध्यात् कर्णस्तिर्यक्कर्णा[5]ग्रकोटियुतेः ॥ १७ ॥

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१४. (ग) १. द्वितीये (ङ) for (द्वितीयं) २. राशिनः for (शशिनः)
(ङ) ३. र्द्दिशो for (र्दिशो)

१५. (घ) १. विक्षेपाग्राद्ग्राह्यं (ग)······विक्षेपाग्राह्यं for (विक्षेपाग्रात्ग्राह्यं)
२. भूपरिलेखे (ग) भूपरिलेषे for (भुपरिलेख)
(ग) ३. पिरिलिख्य for (परिलिष्य)
४. यहां 'प्रमाणेन' के साथ विसर्ग भी लगे हैं ।
(च) १. विक्षेपाग्राद्ग्राह्यं for (विक्षेपाग्रात्ग्राह्यं)
२. भूपरिलेषे for (भुपरिलेखे)
(ङ) १. शशिविक्षेपाग्रेभ्यः ग्राह्यं for (विक्षेपाग्रात्ग्राह्यं)
३. परिलिख्यं for (परिलिष्य) २. भूपरिलेखे for (भुपरिलेखे)

१६. (घ) १. पश्चात्प्रग्रहणे (ग) पश्चात्प्रग्रहणात् for (पश्चापग्रहणे)
२. बिंब (ग) (च) (ङ) for (बिम्बं)
३. शीतकत (ग) शीतकरमध्यात् (ङ) for (शीतकरणमध्यात्)
(ग) ४. प्राक् मोक्षे for (प्राग्मोक्षे) ५. सिद्धज्या (ङ) for (सिद्धायां)
६. विपरीतः (ङ) for (विपरीत)
(च) १. पश्चाप्रग्रहणे for (पश्चापग्रहणे)
(ङ) १. पश्चात्प्रग्रहणे for (पश्चापग्रहणे)

१७. (घ) १. भानुमतो (ग) (च) (ङ) for (भानुमते)
२. बाह्वग्रा (ग) (च) for (बाह्वग्राद्यथा)
(ग) ३. कोटिरं for (कोटि) ५. तियकर्णा for (तिर्यक्कर्णा)
(ङ) भानुमतो for (भानुमते)

परिलेख[1] ग्राह्यस्य ग्राहकमानेन पूर्ववत्कृत्वा ।
तात्कालिकसंस्थानं निमीलनोन्मीलने चैवम् ॥ १८ ॥
विक्षेपगुण[1]त्रिज्या मानैक्यार्द्धो द्धृताप्तचापांशाः ।
आद्यंतयोर्यथादिशमर्कस्येंदौ[2] विपर्यस्थाः[3] ॥ १९ ॥
तत्स्ववलनांशक[1]योगांतर जीवाग्राह्यमानदलघ्रातात्[2] ।
त्रिज्यालब्धज्याग्रे[3] प्रग्रहमोक्षौ[5] प्राग्वर्केंद्वोः[4] ॥ २० ॥
हुतया[4] व्यासार्द्धेनार्कचन्द्रमानार्द्धलिप्तिका[1] गुणया ।
मध्यवलनछाया[5] दक्षिणोत्तरा[2] दिगतवा[3]मध्यात्[6] ॥ २१ ॥

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१८. (घ) १. परिलेषं (ग) (च) for (परिलेखं)

१९. (घ) १. गुणा (ग) गुण्या for (गुण)
२. मर्कस्येंदो (ग) (ङ) for (मर्कस्येंदौ)
३. विपर्ययस्ता (ग) विपर्यस्ताः (ङ) for (विपर्यस्थाः)
(च) १. गुणा for (गुण) २. मर्क्कस्येंदौ for (मर्कस्येंदौ)
३. विपर्ययस्ताः for (विपर्यस्थाः)
१. विक्षेपगुणा for (विक्षेपगुण)

२०. (घ) १. वलनांशयोगान्तर (ग) (ङ) for (वलनांशकयोगान्तर)
२. घातात् (च) (ङ) for (घ्रातात्)
३. ग्रे (च) (ङ) for (ग्रे) ४. प्राग्वदर्केंद्वोः (ग) for (प्राग्वर्केन्द्वोः)
(च) १. वलनांशयोगांतर for (वलनांशकयोगांतर)
४. प्राग्वदर्क्केंद्वोः for (प्राग्वर्केंद्वोः)
(ङ) ५. ग्रहमोक्षौ (प्रग्रहमोक्षौ) ४. प्राग्वदर्केन्द्वोः for (प्राग्वर्केंद्वोः)

२१. (घ) १. लिप्तका (च) for (हुतया) २. ज्यया (ग) for (छाया)
२. दिगनया (ग) दिगमनया मध्या for (दिगतवा)
(ग) ४. हृतव्यासार्द्धेनार्कं for (हुतयाव्यासार्द्धेनार्कं)
(च) ४. हृतया व्यासार्द्धेनार्क्क for (हुतया व्यासार्द्धेनार्कं)
३. दिगनया for (दिगतवा)
(ङ) १. हृतया for (हुतया) ५. मध्यमवलनज्या for (मध्यवलनछाया)
३. दिग्गमनया for (दिगमया) ६. मध्या for (मध्यात्)

प्राग्वत्[४] प्रसार्य विक्षेपलिप्तिका ग्राहकप्रमाणेन ।
विक्षेपाग्राद्[१]ग्राह्यं परिलिख्य[२] ग्राह्य[३]संस्थानम् ॥ २२[५] ॥
त्रिज्या[५] विक्षेपगुणा[१] भक्ते[२]ष्टग्रासकर्णलिप्ताभिः ।
प्राग्वत् फलचाप[३] स्ववलनांश योगांतरं तज्या[४] ॥ २३ ॥
मानार्द्ध गुणाव्यासार्द्ध[३]भाजिता पूर्ववत् प्रसार्या स्यात् ।
कर्ण प्रसार्य मध्यादग्रं[१] मध्येन कर्णाग्रात्[२] ॥ २४ ॥
तात्कालिकसंस्थानं परिलिख्य[१] ग्राहकप्रमाणेन ।
ग्राह्येन[२] मीलोन्मीलने[४] परिलेख[३] एवं वा ॥ २५ ॥

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२२. (घ) १. विक्षेपाग्राद्ग्राह्य (ग) for (विक्षेपायाद्ग्राह्यं)
२. परिलिष्य (ग) परिलेक्ष for (परिलिख्य)
३. ग्रास (ग) (च) (ङ) for (ग्राह्य)
(ग) ४. प्राग्प्रसार्य for (प्राग्वत् प्रसार्य)
(च) १. विक्षेपाग्राद्ग्राह्य for (विक्षेपायाद्ग्राह्यं)
२. परिलिष्य for (परिलिख्य)
(ङ) १. विक्षेपाग्रात् for (विक्षेपायाद्)

२३. (घ) १. गुणाः (च) for (गुणा)
(ग) २. व्यास for (ग्रास) ३. चार्या for (चाप)
४. यथाजिवा for (तज्या)
(च) ५. त्रिद्या for (त्रिज्या) ४. तद्या for (तज्या)
(ङ) ४. तथा जीवा for (तज्या)

२४. (ग) १. दग्रकर्णेन for (दग्रं मध्येन) २. मध्याग्रात् for (कर्णाग्रात्)
३. ३+गुणा व्यासार्द्ध+
(ङ) १. दग्रं कर्णेन for (दग्रं मध्येन) २. मध्याग्रात् for (कर्णाग्रात्)

२५. (घ) १. परिख्य (च) for (परिलिख्य)
२. निमीलनोन्मीलने च (ग)……… नमीलनोन्मीलने च for (ग्राह्येन मीलोन्मीलने च)
(ग) ३. परिलेष for (परिलेख)
(च) ४. +व+
(ङ) २. एवं निमीलनोन्मीलने for (ग्राह्येन मीलोन्मीलने)
४. +च+

प्राच्यपरिविपरिते विपरीतं मध्यवलनमर्केंद्वोः ।
पूर्वदन्यत् सर्वं फल कोष्टौ ग्रहणपरिलेखः ॥ २६ ॥
दृग्गणितप्रग्रहयोरंतरघटीका फलं ग्रहे मध्यौ ।
देशांतरं धनं प्राक् प्रग्रहणे त क्षयः पश्चात् ॥ २७ ॥
प्रग्रहणांतर घटिकाभूपरिधिहता विभाजयेत् षष्टचा ।
फलयोजनेश्चवंत्या प्राग्वत् प्रागपरयोर्देशः ॥ २८ ॥
पातोनखेर्भार्द्धात् च्चक्रोच्चोनाधिकाः कलाभक्ताः ।
तद्गतियुत्याप्तदिनै रासन्ने र्कस्य मासांते ॥ २९ ॥

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२६. (घ) १. विपरीते (ङ) for (विपरिते) २. फलकेष्टौ (ग) for (फलके स्वे)
३. परिलेखाः (ग) (च) (ङ) for (परिलेखः)
(ग) ४. पार for (परि) ५. विपरितं for (विपरीतं)
(च) ४. पर for (परि) १. विपरीते for (विपरिते)
५. मर्क्केंद्वोः for (मर्केंद्वोः) ७. स्थर्वं for (सर्वं)
२. फलकौष्टौ for (फलकोष्टौ)
(ङ) ४. प्राच्यपरे for (प्राच्यपरि) ८. पूर्ववदन्यत् for (पूर्वदन्यत्)
२. फलके स्वे for (फलकोष्टौ)
२७. (घ) १. प्रग्रयो for (प्रग्रहयो) २. घटिका (च) for (घटीका)
३. मध्ये (ङ) for (मध्यौ) ४. तत्क्षयः for (तक्षयः)
(ग) ५. फलग्रहमध्ये for (फलंग्रहेमध्यौ) ६. 'त' लुप्त है ।
(च) १. प्रग्रयो for (प्रग्रहयो) ३. मध्यो for (मध्यौ)
(ङ) २. घटिका for (घटीका) ४. क्षयं for (तक्षयः)
७. +तत्+
२८. (घ) १. योजनेष्ववंत्याः (ङ) for (योजनेश्चवंत्या)
(च) १. योजनेश्ववंत्याः for (योजनेश्चवंत्या)
२९. (घ) १. प्रतौनखेभार्द्धा (ग) पातार्कयुतेभार्द्धाच्च for (पातोनखेर्भार्द्धात्)
२. रासन्नेऽर्कस्य for (रासन्नेर्कस्य)
(ग) ३. क्रार्द्धो (घ) चक्राद्यौ for (चक्रोच्चो)
४. कलाभक्ता (ङ) for (कलाभक्ताः) ५. मासांत्ये for (मासांते)
(च) ३. चक्रार्द्धेनाधिकाः for (चक्राच्चोनाधिकाः) २. ऽर्क्कस्य for (र्कस्य)
(ङ) १. पातार्क युतिर्भार्धात् for (पातोनखेर्भार्द्धात्)
३. चक्राद्योनाधिका for (चक्रोच्चोनाधिकाः)
२. रासन्नोऽर्कस्य for (रासन्नेर्कस्य)

पर्वेंदोः[1] पक्षांते प्रागा[2]धिकोना युतिर्[4]भवति पश्चात् ।
तन्मध्ये न ग्रहणं यदि भानोः पंच जिनभरसाः[3] ॥ ३० ॥
इंदोर्विषया[3] द्वि[1]तमा दिवाकरा त्रिविषया[4]स्त[5]दुच्चस्य ।
व्योमातिधृ[6]तिद्वियु[2]गानि रसश[7]रांश्चन्द्रपातस्य ॥ ३१ ॥
ख[8] नंदा द्वियमाः[4] खा[5]ब्धयो ग्र[1]हाद्या यथेष्ट पर्वगुणाश्रे[2]प्याः ।
पर्वा[3]ण्यष्यति शो[6]ध्याः पा[7]तेऽन्यथातीते ॥ ३२ ॥

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३० (घ) १. पर्वेंदाः for (पर्वेंदोः) २. प्रागधिको (ग) (च) for (प्रागाधिको)
(ग) ३. रसा for (रसाः)
(ङ) २. प्रागधिकोना for (प्रागाधिकोना) ४. "युतिर्" लुप्त
३१ (ङ) १. द्वियमा (ग) (च) (ङ) for (द्वितमा)
२. द्वियुगानि (ङ) द्वियुगानि for (द्वियुगानि)
(ग) ३. विषया for (विषया) ४. स्त्रिविषया (ङ) for (त्रिविषया)
५. स्तदुस्तदुच्चस्य । ५ । २२ । १२ । ४३ । for (स्तदुच्चस्य)
६. घृते for घृति
७. सरा-। १६ । ४२ । ५६ श्चन्द्र for (शरांश्चन्द्र)
(ङ) ५. स्तदुच्चस्य । ५ । १२ । १२ । ५३ for (स्तदुच्चस्य)
७. रसशराश्चन्द्रपातस्य ० । १६ । ४२ । ५६ । ३१ for (रसशरांश्चन्द्रपातस्य)
३२. (घ) १. गृहा (ग) (च) for (ग्रहा)
२. क्षेप्याः (ग) for (श्रेप्याः) द्वितीय पंक्ति का आरम्भिक पद
१. पर्वण्ये (ग) पर्वणोष्यति for (पर्वाण्यष्यति)
(ग) ४. ':' विसर्ग लुप्त है
५. खध्वयो० । ६ । २२ । ४० for (खाब्धयो)
१०. स्तथेष्ट foi (यथेष्ट)
६. शोध्या मध्ये क्षतिक्रांते for (शोध्याः पातेऽन्यथातीते)
७. 'शोध्याः' से आगे के पद लुप्त हैं ।
(च) २. पर्वगुणाः क्षेप्याः ior (पर्वगुणा श्रेप्याः)
३. पर्वाण्येष्यति for (पर्वाण्यष्यति)
(ङ) ८. खं for (ख) ५. खाब्धयो० । ६ । २२ । ४० for (खाब्धयो)
१. गृहाद्या for (ग्रहाद्या) १०. स्तथेष्ट for (यथेष्ट)
६. गुणाः for (गुणा) वि० यहां श्लोकार्ध समाप्त
२. क्षेप्याः for (श्रेप्याः) (वि० श्लोक की दूसरी पंक्ति का आरम्भ)
३. पर्वण्येष्ये for (पर्वाण्यष्यति) ६. शोध्या for (शोध्याः)
७. मध्ये for (पाते) ११. त्वतिक्रांते for (ऽन्यथातीते)

गृहणे यथा[1] रवींद्वोः स्पष्टीकरणाद्य मुक्तवत्कृत्वा[2]
एवं पर्वज्ञानं गृहणज्ञानं[3] स्फुटं गणितात् ॥ ३३ ॥
चत्वारि त्रयुवर्त्तं[1] गृहणात्यर्कस्य[2] सप्तचन्द्रस्य[4] ।
द्रष्टोदयास्त[3]मययोर्क[5]रात्रिदलयोश्च केंद्रस्य ॥ ३४ ॥
सर्वपादानामंतो[1] तिथ्यंत[3]ज्ञानमिंदुभास्करयोः ।
गृहणे च क्तते[2] स्पष्टे जिष्णुसुतब्रह्मगुप्तेन ॥ ३५ ॥

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३३. (ग) १. यथरविंद्वोः for (यथा रवींद्वोः)
२. ज्ञात्वा for (कृत्वा) ३. "ग्रहणज्ञानं" लुप्त पद है

(च) ३. ग्रहणज्ञानस्फुटं for (ग्रहणज्ञानं स्फुटं)

(ङ) २. मुक्तवज् ज्ञात्वा for (मुक्तवत् कृत्वा)

३४. (घ) १. त्रपुवर्त्तं (ग) त्रपुवत्त for (त्रयुवर्त्तं)
२. ग्रहणान्यर्कस्य (ग) (च) (ङ) for (ग्रहणात्यर्कस्य)
३. द्दष्टो (ग) इंद्वोदयास्त समयायार्क for (द्रष्टोदयास्त)
४. शीतरश्मेश्च (ङ) for (सप्तचन्द्रस्य)

(च) १. त्रपुवर्त for (त्रयुवर्त्तं) ३. द्दष्टो for (द्रष्टो)

(ङ) १. चत्वारोऽत्रपर्त्तं for (चत्वारित्रयुवर्त्तं)
३. द्दष्ट्वोदयास्त for (द्रष्टोदयास्त)
५. समया तथाऽर्क for (मययोर्क)

३५. (घ) १. मंते (ग) पदानामन्ते (च) for (पादानामंतो)
२. कृते (ग) चक्रते for (चक्तते)

(घ) ३. तिथ्ये for (तिथ्यन्त)

(च) २. कृते (ङ) for (क्तते)

(ङ) १. सर्वपदानामन्ते for (सर्वपादानामन्तो)
३. तिथ्यन्ते for (तिथ्यंत)

दुरभ्रष्टे ग्रहणे श्रेषेणार्यभटविष्णुचन्द्रस्य ।
दृग्गणितविसंवादः काकतालीयम् ॥ ३६ ॥
स्फुटतिथ्यंतज्ञानं यन्नार्यभटादिभिः कृतमतीतैः ।
ब्राह्मे स्फुटं कृतं तज्जिष्णुसुतब्रह्मगुप्तेन ॥ ३७ ॥
ब्रह्मोक्तोर्केन्दु तदुच्चपातदेशांतरस्फुटीकरणैः ।
स्फुटसिद्धर्कं ग्रहणद्वयं स्फुटमतीतोक्तम् ॥ ३८ ॥
विक्षेपाग्रेषु त्रीन्बिन्दून् प्रग्रहणमध्यमोक्षेषु ।
कृत्वा तन्मन्यद्वयमध्यगयोः सूत्रयोर्योगात् ॥ ३९ ॥

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३६. (घ) १. दूरभ्रष्टे (च) (ङ) for (दुरभ्रष्टे)
२. श्रीषेणार्य (ग) खेणार्य (ङ) for (श्रेषेणार्यभट)
३. चंन्द्रेषु (ग) (च) (ङ) for (चन्द्रस्य)
४. विसंवादात्संवादः (च) for (विसंवादः)
(ग) ५. ग्रहगणितविसंवादात्संवादः for (दृग्गणितविसंवादः)
(च) २. श्रीषेणार्य for (श्रेषेणार्य)
(ङ) ५. ग्रहगणित for (दृग्गणित) ४. विसंवादात् संवादः for (विसंवादः)
६. काकतालीयः for (काकतालीयम्)

३७. (घ) १. यत्रार्य for (यन्नार्य)

३८. (घ) १. मिद्वर्क (घ) मिद्वर्क for (सिद्धर्कं)
(ग) २. ब्रह्मोक्तार्केदुस्तदुच्च for (ब्रह्मोक्तोर्केदु)
३. स्फुटिकरणैः for (स्फुटीकरणैः) ४. द्वितयं न for (द्वयं)
५. स्फुटमतीवोक्तम् for (स्फुटमतीतोक्तम्)
(च) २. ब्रह्मोक्तार्केदु for (ब्रह्मोक्तोर्केन्दु) १. मिंद्वर्क्क for (सिद्धर्कं)
(ङ) २. ब्राह्मोक्तार्केन्दु for (ब्रह्मोक्तोर्केदु) १. मिंद्वर्क for (सिद्धर्कं)
४. ग्रहणद्वितयं for (ग्रहणद्वयं)

३९. (घ) १. कृत्पा for (कृत्वा)
२. तन्मत्स्यद्वय (ग) तन्मत्सद्वय for (तन्मन्यद्वय)
३. मध्यमयोः for (मध्यगयोः)
(च) १. क्रत्या for (कृत्वा) २. तन्मत्स्य for (तन्मन्य)
(ङ) २. तन्मत्स्य for (तन्मन्य)

बिंदु परिलेख[1]रेखा ग्राहकमार्गः प्रसार्य सूत्रे द्वे ।
आद्यंताभ्यां मध्यम[4]माछेद्य[2] स्थुल[3] एवं[5] वा ।। ४० ।।
बिन्दु द्वयांतरं[2] स्थितिदलेन ह्रुत[3]मिष्टनाडिका[4]गुणितम् ।
ग्राह्य[6]फलांगुलस्थं[5] ग्राहकमानेन परिलेखः[1] ।। ४१ ।।
इष्ट ग्रासोर्केंद्वो[1]र्निमीलनोन्मीलनं[2] च भानुमतः[5] ।
त्रषुवर्तः[3] प्राग्मध्यात् पश्चाद्विष्टांगुले[4] स्थेन ।। ४२ ।।

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४०. (घ) १. परिलेषरेषा (ग) for (परिलेखरेखा)
२. माछोद्य (ग) माछाद्य for (माछेद्य)
३. स्थूल (ग) (च) (ङ) for (स्थुल)

(च) १. परिलेषरेषा for (परिलेखरेखा)

(ङ) ४. मध्यग for (मध्यम) २. मुच्छाद्य for (माछेद्य)
५. मेवं वा for (एवं वा)

४१. (घ) १. परिलिख्य (ग) परिख्यः for (परिलेखः)

(ग) २. बिंदुद्वयान्तर for (बिन्दुद्वयांतरं) ३. हृत (च) (ङ) for (ह्रुत)
४. नालिका for (नाडिका) ५. छा for (स्थं)

(च) १. परिलेख्य for (परिलेखः)

(ङ) १. परिलिख्य for (परिलेखः) ६. ग्राह्यं for (ग्राह्य)

४२. (घ) १. ऽर्केंद्वो (ग) इष्टग्रार्कंदो for (इष्टग्रासोर्केंद्वो)
२. मीलने (ग) मिलने for (मीलनं)
३. त्रपुवर्त्तः (ग) (च) for (त्रषुवर्तः)
४. पश्चादुद्वेष्टांगुल (ग) (च) for (पञ्चाद्विष्टांगुले)

(च) १. ऽर्क्कद्वो for (ऽर्केंद्वो) २. मीलने (ङ) for (मीलनं)

(ङ) १. ऽर्केन्द्वो for (केंद्वो) ५. भानुमतोः for (भानुमतः)
३. उवरितः for (त्रषुवर्तः)
४. पश्चाद्वेष्टाङ्गुल for (पश्चाद्विष्टांगुले)

मध्यस्य[1] दिनांत्य नवांतरं[2] मिष्टघटिकाभिः[4] ।
स्थित्यर्द्धनाडिकाद्रत[3]मृणधन[5]मूनाधिके मध्ये ॥ ४३ ॥
आद्यन्ते वान्कृत्वा[2] विक्षेपः[1] कोटिरूक्तवद्ग्रासः ।
विक्षेपान्तरमेवं गुणमिष्टग्रासलिप्ताभिः[3] ॥ ४४ ॥
मध्यग्रासकला हृतमृणधन[1] चोक्त[4]वत्स्व[5]विक्षेपः[2] ।
तेन ग्रासात्कालः कालादसकच्च[6] विक्षेपः[3] ॥ ४५ ॥
गृहणोत्तरं न देयं शपथैरपि दत्त सुकृत्[4] नाशाद्यैः ।
गृहणं स्फुट[1]मिहा[2]स्फुटमार्यभटाद्यै[5]र्यतस्तंत्रैः[3] ॥ ४६ ॥

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४३. (घ) १. मध्यस्याद्येनांत्ये (ग) मध्यस्याद्येनांते for (मध्यस्यदिनांत्य)
२. गुणितमिष्ट (ग) गुणीतमिष्ट for (मिष्ट)
३. द्धृत (ग) हृत for (द्रत)
(ग) ४. घटिभि for (घटिकाभिः) ३. धनमृण for (मृणधन)
(च) १. मध्यस्याद्येनांत्यनवांतरं for (मध्यस्य दिनांत्य नवांतरं)
२. गुणितमिष्टघटिकाभिः for (मिष्टघटिकाभिः) ३. हृत for (द्रत)
(ङ) १. मध्यस्याद्येनान्तेन for (मध्यस्यदिनांत्य न)
२. वाऽन्तरं गुणित for (वांतरं) ३. हृत for (द्रत)

४४. (घ) १. विक्षे (ज्ञे) यः for (विक्षेपः)
(ग) २. वा कृत्वा for (वान्कृत्वा) ३. विलिकाभिः for (लिप्ताभिः)
(ङ) २. च पृषत्के for (वान्कृत्वा)

४५. (घ) १. हृतमृणंधनं (ग) हृतमृणधन (च) for (हृतमृणधन)
२. विक्षेण (ग) विक्षेपं for (विक्षेपः)
३. दसकृच्च (ङ) (च) for (दसकच्च)
(ग) ४. वोक्त for (चोक्त) ५. ख for (स्व)
६. कालदसत्कृच्चविक्षेप for (कालादसकच्च विक्षेपः)
(च) २. विक्षे for (विक्षेपः)
(ङ) १. हृतमृणंधनं for (हृतमृणधन)

४६. (ग) १. 'स्फुट' लुप्त है । २. 'मिहा' लुप्त है ।
३. तंतैः for (तंत्रैः)
(च) ४. सुकृत for (सुकृत) १. स्पष्ट for (स्फुट)
(ङ) ४. सुकृतनाशाय for (सुकृत्नाशाद्यैः) २. मार्यभट for (मिहास्फुट)
५. श्रीषेणाद्यै for (मार्यभटाद्यै) ३. र्यतस्तन्न for (र्यतस्तंत्रैः)

परिलेखो[1] बलिनज्या[5] विक्षेपाद्येषु षोड़षो[2]ऽध्यायः।
ग्रहणोत्तरमर्केन्द्वोः[3] षट्चत्वारिंशदार्याणाम् ॥ ४७ ॥
[4]इति श्री ब्रह्मगुप्ते ग्रहणाधिकारः
षोडशोऽध्यायः समाप्तः

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४७. (घ) १. परिलेषो (ग) परिलेष for (परिलेखो)
२. षोडशोऽध्यायः (ङ) for (षोडशोऽध्यायः)
३. मर्केन्द्वो for (मर्केन्द्वोः)
४. 'इति' से 'समाप्तः' तक पाठ अंकित नहीं।

(ग) ५. वलन for (बलिन)
४. इति श्री ब्रह्मसिद्धांते ग्रहणोत्तराध्यायः षोडशः for (इति श्री ब्रह्मगुप्ते ग्रहणाधिकारः षोडशोऽध्यायः समाप्तः)

(च) १. परिलेषो for (परिलेखो) ५. वलनद्या for (वलिनज्या)
२. षोडशो for (षोडषो) ३. मर्क्केन्द्वोः for (मर्केन्द्वोः)
४. 'इति' से 'समाप्तः' तक लुप्त।

(ङ) १. परिलेख for (परिलेखो) ५. वलनजीवा for (बलिनज्या)
४. इति श्री ब्राह्मस्फुट सिद्धान्ते ग्रहणोत्तराध्यायः षोडशः for (इति श्री ब्रह्मगुप्ते ग्रहणाधिकारः षोडषोऽध्यायः समाप्तः)

अथ शृङ्गोन्नत्युत्तराध्यायः

सप्तदशः

भुजकोटिशशिमान[1] शुक्लपरिलेख[2] सूत्रपरिलेखान्[3] ।
प्रतिदिवसं प्रतिघटिकं यो वेत्तीं[4]दुद[5] यज्ञः सः ॥ १ ॥
पराच्य[1] परादिगभिमुखं[5] शुक्लेतर[6]पक्षयोर्लिखेतं[3] भूमौ ।
अपवर्त्तेष्टे[7]नैकेन राशिना[8] कोटिभुजकर्णात्[4] ॥ २ ॥
परिकल्पार्कं[6] बिन्दु[3] तस्माद्बाहुं यथादिशं[4] कृत्वा[7] ।
बाहुग्रात्[1]प्राच्यपरां कोटिं[5] तिर्यक्कथं[2] कर्णः ॥ ३ ॥

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१. (घ) १. छेदभुजकोटिकर्णशशि (ग) भुजकोटिकर्णशशि for (भुजकोटिशशि)
२. परिलेष for (परिलेख) (ग) 'परिलेख' लुप्त है ।
३. परिलेषान् (ग) परिलेखात् for (परिलेखान्)
(ग) ४. वेत्तं for (वेत्ती) ५. हृदयज्ञः for (दुंदयज्ञः)
(च) १. भुजकोटि कर्णशशिमान for (भुजकोटिशशिमान)
२. परिलेष for (परिलेख) ३. परिलेषान् for (परिलेखान्)
४. वेत्तीदूंदं for (वेत्तींदुद)
(ङ) २. सित for (परिलेख) ३. लेखात् for (लेखान्)
४. वेत्ति for (वेत्ती) ५. स तन्त्रहृदयज्ञः for (दुंदयज्ञः सः)

२. (घ) १. प्राच्य (ग) (च) (ङ) for (पराच्य)
२. मुंषं for (मुखं) ३. लिषेत (ग) लिखेद्भूमौ for (लिखेत भूमौ)
४. कर्णान् (ङ) (च) for (कर्णात्)
(ग) ५. पदिगभि मुखं for (परादिगभिमुखं)
६. तरतर for (तर) ७. अपवर्त्यैकेनेष्टेन (ङ) for (अपवर्त्तेष्टे नैकेन)
८. वाशिना for (राशिना)
(च) २. मुषं for (मुखं) ३. लिषेत् for (लिखेत)
(ङ) ४. लिंखेत् (लिखेत)

३. (घ) १. बाह्वग्रात् (ग) (ङ) for (बाहुग्रात्)
२. तिर्यक् स्थतं (ग) तिर्यक्स्थितं कर्णम् ॥ ३ ॥
(ग) ३. बिंदुं (ङ) for (बिन्दु) ४. यथादिशिं (यथादिशं) ५. कोटि for (कोटिं)
(च) ६. परिकल्पार्क्कं for (परिकल्पार्कं) २. तिर्यक्स्थं for (तिर्यक्कथं)
(ङ) ६. परिकल्प्यार्कं for (परिकल्पार्कं)
७. दत्त्वा for (कृत्वा) २. तिर्यक्स्थितंकर्ण for (तिर्यक्कथं कर्णः)

कर्णाग्रे[1] चन्द्रमसं परिलेख्य[2] सितं प्रवेश्यकर्णेन ।
शशिबिंबे[3] शुक्लाग्रात्परिलेख[4]समेन सूत्रेण ॥ ४ ॥
कर्णगतस्थे[1]नेन्दो[3] शुक्ल परिलेख्य[4] पश्चिमाभिमुखः[5] ।
राशिषु मेष[2]तुलादिषु संशोध्य दिवाकरं[6] चन्द्रात् ॥ ५ ॥
पूर्वाभिमुखः[3] कर्कट[2]मकरादिषु भवति शुक्लसंस्थानम् ।
एवं वा संस्थानं परिलेख्येन्दु[1] प्रसाध्य दिशः ॥ ६ ॥
बाहुज्येंदुदलगुणाकर्णविभक्ता भुजोन्यदिक्[2] चन्द्रे ।
कर्णोभुजागतश्चन्द्रमध्यगः[3] पूर्वच्छेषम्[1] ॥ ७ ॥
प्राच्यपरे[1] विपरीते[2] फलकेन्यत्सर्वमुक्त[5]वत्[3]कार्यम्[6] ।
शृङ्गोन्नतिपरिलेखाश्चत्वारः शीत[4]किरणस्य ॥ ८ ॥

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४. (घ) १. कर्णाग्र for (कर्णाग्रे) २. परिष्य (ग) परिलिख्य for (परिलेख्य)
(ग) ३. बिंबे सूत्रां for (बिंबे शुक्ला)
(च) २. परिलेष्य for (परिलेख्य) ४. परिलेष for (परिलेख)
(ङ) २. परिलिख्य for (परिलेख्य)

५. (घ) १. कर्ण गतिस्थे (ग) (ङ) for (कर्णगतस्थे) २. मेख for (मेष)
(ग) ३. नेंशे for (नेंन्दो) ४. परिलिख्य (ङ) for (परिलेख्य)
५. मुखम् (ङ) for (मुखः) ६. दिकारं for (दिवाकरं)
(च) १. कर्णगतिस्थेनेदो for (कर्णगतस्थेनेंदो)
४. शुक्लं परिलेख्य for (शुक्लं परिलेख्य)
(ङ) ३. नैंशे for (नेंन्दो) ७. शुक्ले for (शुक्ल)

६. (ग) १. परिलेखेन्दु for (परिलेख्येन्दु)
(च) २. कक्र्कट for (कर्कट) १. परिलिख्येंदु for (परिलेख्येन्दु)
(ङ) ३. मुखं for (मुखः) १. परिलिख्येन्दु for (परिलेख्येन्दु)

७. (घ) १. पूर्ववछेषम् (ग) पूर्ववछेशम् for (पूर्वछेषम्)
(ग) २. भुजात्य दिक्केद्रे for (भुजोन्यदिक्चन्द्रे) ३. मध्यतः (ङ) for (मध्यगः)
(ङ) २. भुजान्यदिक् for (भुजोन्यदिक्) १. पूर्ववच्छेषम् for (पूर्वछेषम्)
(च) १. पूर्ववछेषं for (पूर्वछेषम्)

८. (ग) १. प्राच्यररे for (प्राच्यपरे) २. विपरिते for (विपरीते)
३. मुक्तवछेषम् for (मुक्तवत्कार्यम्) ४. सीत for (शीत)
(च) ५. फलकेन्य सर्वमुक्त for (फलकेन्यत्सर्वमुक्त)
(ङ) ६. वच्छेषम् for (वत्कार्यम्)

ग्रहयोर्गेंदुच्छाया [1]ग्रहदयोस्तमयभग्रह[2]युतीनाम् ।
[3]तत्स्वक्रान्ति[5]ज्याद्युत्तराणि भग्रहयुतौ न [4]पृथक् ॥ ९ ॥
इति परिलेखाध्यायः[3] शशांक शृंगोन्नते[1]र्भुजाद्येषु ।
[4]शशि[5]शृङ्गोन्नत्युतरमार्यादशकेन सप्तदशः ॥ १० ॥
[2]इत्ति सप्तदशाध्यायः समाप्तः

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९. (ग) १. ग्रहोदयास्त (च) (ङ) for (ग्रहदयोस्त)
२. मुनिनां for (युतीनाम्) ३. तत्क्रान्तिज्याप्पा (घ) for (तत्क्रान्तिज्याद्यु)
४. प्रथक् for (पृथक्)

(च) ५. द्या for (ज्या)

(ङ) २. ग्रह मुनीनां for (ग्रह युतीनां)
३. तत्क्रान्तिज्या for (तत्स्वक्रान्तिज्या)
५. प्रश्नोत्तराणि for (द्युत्तराणि)

१०. (घ) १. भुजोज्येषु (ग) भुजाद्येषु for (र्भुजाद्येषु)
२. 'इति' से 'समाप्त' तक अंकित नहीं है ।

(ग) ३. : लुप्त हैं ५. शृंगोन्युत्तर for (शृङ्गोन्नत्युतर)
६. मार्यादसकेन for (मार्यादशकेन)
२. इति ब्रह्मसिद्धांते सप्तदशोध्यायः for (इत्ति सप्तदशाध्यायः समाप्तः)
४. राशि for (शशि)

(च) २. 'इति' से 'समाप्तः' तक लुप्त

(ङ) २. इति श्रीब्राह्मस्फुटसिद्धान्ते शृङ्गोन्नत्युत्तराध्यायः सप्तदशः
for
(इति सप्तदशाध्यायः समाप्तः)

अथ कुट्टकाध्यायः

अष्टादशः

प्रायेण यतः प्रश्नाः कुदाकाराद्रतेन शक्यंते ।
ज्ञातुं वक्षामि ततः कुदाकारं सह प्रश्नैः ॥ १ ॥
कुदकर्णं धनाव्यक्त मध्यमाहरण वंण्यता वितकैः ।
आचार्यस्तंत्रविदां ज्ञातैर्वर्ग प्रकृत्याच्च ॥ २ ॥
अधिकाग्रभागहारा दूनाग्रछेदभाजिता शेषम् ।
यत्तत्परस्य ह्रतं लब्धमध्योधः पृथक् स्थाप्यम् ॥ ३ ॥
शेषं तथेष्टगुणितं यथाग्रयोरंतरेण संयुक्तम् ।
शुध्यति गुणकः स्थाप्यो लब्धं चांत्यादुपांत्यगुणाः ॥ ४ ॥

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१. (घ) १. २ कुट्टाकाराद्दते (ग) कुट्टाकाराद्दते for (कुदाकाराद्रते)
३. वक्ष्यामि (ग) (च) (ङ) for (वक्षामि)
(ग) ४. प्रश्ना for (प्रश्नाः) ५. कुट्टाकारं (ङ) for (कुदाकारं)
(च) २. द्दतेन for (द्रतेन)
(ङ) १. कुट्टाकाराद्दते for (कुदाकाराद्रते)

२. (घ) १. कुट्टकर्णं for (कुदकर्णं)
(ग) १. कुट्टकखर्णंधना for (कुदकर्णंधना)
२. कर्णभावितकैः (ङ) for (वंण्यतावितकैः)
३. विदा for (विदां) ४. वर्ग for (वर्ग)
(च) ५. च for (च्च)
(ङ) १. कुट्टकखर्ण for (कुदकर्णं) ६. हरणैक for (माहरण)

३. (घ) १. छेषम् (च) (ङ) for (शेषम्)
२. यत्तत्परस्परह्वतं (ग) यत्परस्परह्वतं (ङ) for (यत्तत्परस्यह्रतं)
३. मध्येधः (ग) मधोऽधः (ङ) for (मध्योधः)
(ग) ४. भावहारा for (भागहारा) ५. प्रथक् for (पृथक्)
(च) ३. मध्येधः for (मध्योधः)
(ङ) ६. दूनाग्रच्छेद for (दूनाग्रछेद)
४. (ग) १. गुणः (ङ) for (गुणाः)
(ङ) २. यथाऽग्रयो for (यथाग्रयो)

स्तोद्धींत्ययुतोग्रातो[१][२] हीनाग्रछेदभाजितः शेषम् ।
अधिकाग्रछेदाहृतमधिकाग्रयुतं[३] भवत्यग्रम् ॥ ५ ॥
छेदवधस्य द्वियुगछेद[१] वधोयुगतं[५][२] द्वयोरग्रम्[३] ।
बुधकारेणैवं[४] त्र्यादिग्रहयुगगतानयनम् ॥ ६ ॥
यो जानाति युगादिं[२] ग्रहयुगपातैः[३] पृथक् पृथक्[४] तिथितैः[५] ।
द्वित्रिचतुः प्रभृत्तिनां[१] कुट्टाकारं[६] स जानाति[७] ॥ ७ ॥

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५. (घ) १. स्वोद्धींतियुतो (ग) स्वोर्थत्यियुतो for (स्तोद्धींत्ययुतो)

(ग) २. ग्रांतो for (ग्रातो) ३. हृत for (हृत)

(च) १. स्तोद्धींत for (स्तोद्धींत्य)
(ङ) १. स्वोर्ध्वोऽन्त्ययुतो for (स्तोद्धींत्ययुतो)
२. ऽग्रान्तो for (ग्रातो) ३. च्छेदहृत for (छेदाहृत)

६. (घ) १. द्वियुगं (ग) (च) (ङ) for (द्वियुग)
३. रर्ग्रम् for (रग्रम्) २. युगगतं (ग) युगमतं for (युगतं)
४. कुधकारेणैवं (ग) कुट्टाकारेणैवं (ङ) for (बुधकारेणैवं)

(ग) ५. छोदवहो for (छेदवधो)

(च) २. युगगतं (ङ) for (युगतं) ४. कुद्यकारेणैवं for (बुधकारेणैवं)

७. (घ) १. प्रभृतीनां (ङ) (ग) प्रभृतिनां for (प्रभृत्तिनां)

(ग) (वि०—यह श्लोक इस प्रति में श्लोक संख्या १५ पर है)
२. युगादीग्रह for (युगादिग्रह) ३. युगजातैः for (युगपातैः)
४. प्रथक् २ for (पृथक् पृथक्) ५. कथितैः for (तिथितैः)
६. कुट्टकारं for (कुट्टाकारं) ७. जाति for (जानाति)

(च) ३. युगः यातैः for (युगपातैः)
४. पृथक्प्रथक्कतिथितैः for (पृथक् पृथक् तिथितैः)
१. प्रभृतीनां for (प्रभृत्तिनां)
२. युगादि for (युगादिं) ३. ग्रहयुगयातैः for (ग्रहयुगपातैः)
(वि०—श्लोक संख्या १५ है)

भगणादिशेषमग्रं छेदहृतं[1] ख[2] चर[5] दिनजशेषहृतम्[3] ।
अनयोरग्रं भगणादि दिनजशेषोद्धृतं[6] द्यगुणः[4] ॥ ८ ॥
अथवा[2] जिनजभगणादिशेषं येन गुणं मंडलादि शेषोनं[3] ।
शुध्यति विभाजितं स्वेन भागहारेण सद्यगुणः[1] ॥ ९ ॥
मंडल राश्यंशकला विकलाशेषादभिष्टतः[1] कथितान ॥
आनयति दिनगणं यः कुठाकारं[2] स जानाति ॥ १० ॥

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८. (घ) १. छेदहृतं (ग) (च) (ङ) for (छेदहृतं)
२. खंच (यहां मूल में 'र' नहीं है) for (खचर)
३. हृतम् (च) (ङ) for (हृतम्)
४. क्वगणः (ग) द्युगणः for (द्यगुणः)
(ग) ५. च for (चर)
६. भगणादिधृतं for (भगणादिदिनजशेषोद्धृतं)
(वि०—इसकी श्लोक संख्या ७ है) (ङ)
(च) २. खच for (खचर) ४. द्युगणः (ङ) for (द्यगुणः)
(वि०—इसकी क्रमसंख्या ७ है)

९. (घ) १. गणः for (गुणः)
(ग) २. यह श्लोक 'दिनज' से आरम्भ होता है, (ङ)
३. शेषकयोः (ङ) for (शेषोनं)
दूसरी पंक्ति बिल्कुल भिन्न है—
"सदृशछेदो धृतयोस्तद्घातमहर्गण द्यमतः" ।।८।।
(च) १. सद्युगणः for (सद्यगुणः)
(ङ) २. 'अथवा' लुप्त, दिनज for (जिनज)
दूसरी पंक्ति निम्नांकित—
सदृशच्छेदोद्धृतयोस्तद्घातमहर्गणाद्यमनः for (शुध्यति विभाजितं स्वेन भागहारेण सद्यगुणः)
(वि—इसकी क्रमसंख्या ८ है)

१०. (घ) १. दभीष्टतः कथितान् for (दभिष्टतः कथितान)
२. कुट्टाकारं for (कुठाकारं)
(च) १. दभीष्टतः for (दभिष्टतः) २. कुदाकारं for (कुठाकारं)
(ङ) श्लोक उपलब्ध नहीं।

यो जानाति[२] युगगतं कथितादयिमास[४] शेषकादिष्टात् ।
अवभाव[१] शेषतो वा तद्योगाद्वासकुट्टज्ञः[३] ॥ ११ ॥
एकेष्टदिवसघटिका विनाडिका मंडलादिशेषकयोः ।
सद्रश[१]छेदो धृतयो[२]स्तघात्[३] महर्गणाद्यमतः ॥ १२ ॥
हतयो[३]परस्परं यच्छेषं[४] गुणकारभागहारकयोः ।
तेन हतौ[२] निछेदौ[५] तावेव परस्परं हतयोः[१] ॥ १३ ॥
लब्धमध्येधः[३] स्थाप्यं तथेष्ट गुणकारसंगुणं शेषम्[४] ।
शुध्यति तथैक[१]हीनं गुणकः स्थाप्यः पलं[२] चांत्यात्[५] ॥ १४ ॥

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११. (घ) १. अवमाव (ग) (च) (ङ) for (अवभाव)
(ग) (वि०—इसकी श्लोक संख्या २५ है)
२. यो युगगतं for (यो जानाति युगगतं)
(च) ३. कुदज्ञः for (कुट्टज्ञः)
(ङ) (वि---श्लोक संख्या २५ है)
२. जानाति यो for (यो जानाति) ४. दधिमास for (दयिमास)
१२. (घ) १. सद्दश (च) for (सद्रश) २. हृतयो (च) for (धृतयो)
३. स्तद्यात for (स्तघात्)
(ग) यह श्लोक इस प्रति में उपलब्ध नहीं है ।
(च) ३. तद्यात् for (तघात्)
(ङ) श्लोक अनुपलब्ध है ।
१३. (घ) १. हृतयोः (ग) (ङ) for (हतयोः)
२. हृतौ (ग) (च) for (हतौ)
(ग) ३. हृतयोः (च) for (हतयो)
(वि० — इसकी श्लोक संख्या ६ है) (ङ)
(ङ) ३. हृतयोः for (हतयो) ४. यच्छेषं for (यछेषं)
५. निश्छेदौ for (निछेदौ)
१४. (घ) १. यथैक (च) (ङ) for (तथैक)
२. स्थाप्यपलं (ग) स्थाप्यफलं for (स्थाप्यः पलं)
(ग) ३. लब्धमध्योध for (लब्धमध्येधः) ४. शेषे for (शेषं)
५. वांत्यात् for (चांत्यात्)
(वि०—इसकी श्लोक संख्या १० है) (ङ)
(च) ५. चाप्तात् or चात्यात् for (चांत्यात्)
(ङ) ३. लब्धमधोऽधः for (लब्धमध्येधः)

अग्रांत्य[1]मुपांत्येना[6] स्वार्द्धो[2] गुणितोंत्य[7] संयुतो भगणः[3] ।
छेदभागहारे[4]णैवं स्थिरकटुकः[5] शेषम् ॥ १५ ॥
इष्ट[7]भगणादिशेषात् स्वकुटक[1]गुणात् स्वाभागहार[2] हृतात्[3] ।
शेषं द्युगणोहृत[4] निरपर्वत[5] गुणभागहारं[6] युतः ॥ १६ ॥

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१५. (घ) १. अग्रांत (ग) (च) (ङ) for (अग्रांत्य)
३. भक्तः (ग) (च) for (भगणः)
४. निछेदभागहारे for (छेदभागहारे)
५. कुट्टकः (ङ) for (कटुकः)
७. गुणितोप्त (त्य) (च) for (गुणितोंत्य)

(ग) २. स्वेर्धो for (स्वार्द्धो)
६. मुपांत्येन (ङ) for (मुपांत्येना)
(वि०—इसकी श्लोक संख्या ११ है)
४. निछेद for (छेद) ५. कुदकः for (कटुकः)

(ङ) २. स्वोर्ध्वो for (स्वार्द्धो) ३. भक्तः for (भगणः)
४. निः शेष for (छेद)

१६. (घ) १. कुट्टक (ङ) for (कुटक)
२. गुणात्स्वभाग (ग) गुणान् स्वभाग for (गुणात्स्वाभाग)
३. हृतात् (ग) हृतान् for (हृतात्)
४. गत (ग) भगणोगत for (द्युगणोहृत)
५. निरपवर्त्त (ग) (च) (ङ) for (निरपर्वत)
६. भागहारयुतः (ग) गुणभागहारयुता for (गुणभागहारंयुतः)

(ग) (वि०—इसकी श्लोक संख्या १२ है)

(च) ७. दष्ट for (इष्ट) १. कुदक for (कुटक)
२. गुणात्स्वभाग for (गुणात्स्वाभाग)
३. हृतात् for (हृतात्) ४. गत for (हृत)
६. गुणभागहारयुतः (ङ) for (गुणभागहारंयुतः)

(ङ) २. गुणात्स्वभाग for (गुणात्स्वाभाग) ४. गत for (हृत)

एवं समेषु विषमेष्वृणं[1] धनं धनमृणं यदुक्तं तत् ।
ऋणधनयोर्व्यस्तत्वं[4] गुण्य[5]प्रक्षेपयोः[2] कार्यम् ॥ १७ ॥
गुणकच्छेदः[1] छेदो गुणको धनमृण[3]धनं कार्यम् ।
वर्गं[4] पदं पदकृति[6] रंताद्वैपरित[5] माद्यं[2] तत् ॥ १८ ॥
अंशक शेषा त्र्यूनास्तप्त[2] हतान्मूल[1] मूनमष्टाभिः ।
नवभिर्गुणं सरूपं कदा शतं बुधदिने सवितुः ॥ १९ ॥

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१७. (घ) १. विषमेष्वृणं (ग) पुणधन for (विषमेष्वणं)
(ग) ४. व्यस्तत्वं for (र्व्यस्तत्वं) ५. गुण्यम् for (गुण्य)
(वि०—इसकी श्लोक संख्या १३ है) (ङ)
(च) १. विषमेष्वृणं for (विषमेष्वणं) २. प्रक्षेपयो for (प्रक्षेपयोः)
(ङ) १. विषमेष्वृणं for (विषमेष्वणं)

१८. (घ) १. छेदः (ग) छेद (च) for (छेदः छेदो)
२. वैपरीत for (वैपरित)
(ग) ३ मृणमृणं for (मृण) ४. वागपदं for (वर्गपदं)
५. रंत्याद्विपरित for (रंताद्वैपरित)
(वि०—इसकी श्लोक संख्या १४ है) (ङ)
(ग) +तिथिमानदिनेष्विष्टा ये ऽर्काद्यास्ते पुनः कदा तेषु ।
इष्टग्रहवारे यः कथयति कुट्टकज्ञः सः ॥ ८ ॥+
इसकी श्लोक संख्या १८ के स्थान में ८ लिखी गई प्रतीत होती है ।
(च) 'श्लोक' लुप्त
(ङ) (वि०—इसकी क्रमसंख्या १८ है)
१. ग्रहवारेषु for (ग्रहवारे)
(च) ४. वर्गं पदं for (वर्गपदं) ६. पदेकृति for (पदकृति)
५. रंताद्वैपरीत for (रंताद्वैपरितं)
(ङ) १. गुणकश्छेदश्छेदो for (गुणकछेदः छेदो)
४. वर्गः पदं पदं for (वर्गपदं पद)
५. रन्त्याद्विपरीत for (रंताद्वैपरित)

१९. (घ) १. हृतान् for (हतान्)
(ग) (वि०—इसकी श्लोक संख्या २७ है)
(ङ) (वि०—इसकी श्लोक संख्या २७ है)
२. शेषात्त्र्यूनात् for (शेषात्र्यूनाम्)
१. सप्तहृतात् for (तप्तहतान्)

त्र्यूना[5]धिमासः शेषात्[1] मूलध्व्य[2]धिकं विभाजितं षड्भिः ।
द्व्यूनं[6] वर्जित[3] मधिकं नवभि र्नवति[4] कदा भवति ॥ २० ॥
अवमावशेष[4] वर्गोन्येको[5]विंशति विभाजितोध्व्य[1]धिक ।
अष्टगुणे[6] दशभक्ते[2] द्वियुते[3]ष्टादशकदा भवति ॥ २१ ॥
इष्टभगणादिशेषा[4] द्युगणस्तत्कु[1]ट्टकेन संयुक्तः
तच्छेद[5]दिनैस्तावद्दिनवारो यावदि[2]ष्टस्य[3] ॥ २२ ॥

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२०. (घ) १. शेषान्मूलं (ग) for (शेषात् मूल) २. द्वयधिकं (ग) (च) for (ध्व्यधिकं)
३. वर्गित (ग) (च) for (वर्जित) ४. न्नवतिः (ग) नवभिः for (नवतिः)
(ग) (वि०—इसकी श्लोक संख्या २८ है)
५. न्यूनाधिमास for (त्र्यूनाधिमास) ६. द्वयूनं २ for (द्व्यूनं)
(च) १. शाषान्मूलं for (शेषात्मूल) २. द्वयधिकं for (ध्व्यधिकं)
४. न्नवतिः for (नवति)
(ङ) (वि०—इसकी श्लोक संख्या २८ है)
५. च्यूनाधिमास for (त्र्यूनाधिमासः)
१. शेषान्मूलं for (शेषात्मूल) २. द्वयधिकं for (ध्व्यधिकं)
६. द्वयूनं for (द्व्यूनं) ३. वर्गित for (वर्जित)
४. नवतिः for (नवति)
२१. (घ) १. द्वयधिकः (ग) (च) (ङ) for (ध्व्यधिकः)
१. देशभक्तो (ग) (च) for (दशभक्तो)
३. द्वियुतोऽष्टादश (ग) (च) for (द्वियुते)
(ग) (वि०—इसकी श्लोक संख्या २९ है)
४. शेषे for (शेष) ५. व्येको for (न्येको)
६. गुणो for (गुणे)
(ङ) ५. व्येको for (न्येको)
(वि०—इसकी श्लोक संख्या २९ है)
२२. (ग) १. कुटकेन for (कुट्टकेन) २. दिष्टः for (दिष्ट)
३. स्यात् for (स्य)
(वि०—इसकी श्लोक संख्या १९ के स्थान में ९ है)
(च) १. कुदकेन for (कुट्टकेन)
(ङ) (वि०—श्लोक संख्या १९ है)
४. शेषाद् for (शेषा) ५. तच्छेद for (तछेद)
२. ३. यावदिष्टः स्यात् for (यावदिष्टस्य)

भगरणाद्यमिष्टशेषं कदेंदुदिवसे खेर्गुरू दिने वा ।
ज्ञदिने[3] वायः कथयति[1] कुदाकारं[2] स जानाति ।। २३ ।।
ज्ञदिने यदंशशेषं विकलाशेषं कदा न[1] दिंदु दिने ।
भानोरथवा शशिनो यः कथयति कुटकज्ञः[2] सः ।। २४ ।।
इष्टेषुमान दिवसे[4] द्विमासान्मून[1] रात्रिशेषे[5] वा ।
भूयस्ते यः कथयति पृथग्[2] पृथग वा कुदज्ञः[3] ।। २५ ।।

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२३. (घ) १. कथति (च) for (कथयति)
२. कुट्टाकारं (ग) कुट्टकारं for (कुदाकारं)
(ग) ३. ज्ञदिनैराशयः for (ज्ञदिनेवायः)
(वि०—इसकी श्लोकसंख्या १६ के स्थान में केवल ६ लिखी है)
(च) १. कुट्टाकारं ror (कुदाकारं)
(ङ) (वि०—श्लोकसंख्या १६ है)
३. राशीन् for (वायः)   २. कुट्टाकारं for (कुदाकारं)

२४. (घ) १. तदिंदु (ग) (च) (ङ) for (नदिंदु)
२. कुट्टकज्ञः (ग) for (कुटकज्ञः)
(ग) (वि०—इसकी श्लोक संख्या १७ के स्थान में ७ है)
(च) २. कुदकज्ञः for (कुटकज्ञः)
(ङ) (वि०— क्रमसंख्या १७ है)
१. कुट्टकज्ञः for (कुटकज्ञः)

२५. (घ) १. मासन्मून for (मासान्मून)
२. पृथगपृथग्वा (ग) प्रथक् पृथग् वा स for (पृथग् पृथग वा)
३. कुट्टज्ञः (ग) for (कुदज्ञः)
(ग) (वि०—इसकी श्लोक संख्या २६ है)
१. न्यून for (न्मून)
४. दिवसेष्वधिमास for (दिवसे द्विमास)
(च) १. मासन्मून for (मासान्मून)   २. पृथगपृथग्वा for (पृथग् पृथगवा)
(ङ) (वि०—इसकी क्रमसंख्या २६ है)
४. दिवसेष्वधि for (दिवसे द्वि)   १. मासन्यून for (मासान्मून)
५. रात्र शेषे for (रात्रिशेषे)   २. पृथक् for (प्रथग्)
२. पृथग् वा for (पृथग वा)   ३. स कुट्टज्ञः for (कुदज्ञः)

निछेदभागहाराद्राश्यादि कलानाहताद्रुक्तात् ।
भगणकलाभिर्लब्धं मंडलशेषं दिनगणोस्मात् ॥ २६ ॥
एवं राश्यंश कलाशेषाण्यहर्गणः प्राग्वत् ।
नष्टस्थानेष्विष्टानं कान् कृत्वोक्त वछेशषम् ॥ २७ ॥
यो राश्यादीन् द्रष्ट्वा मध्यस्येष्टस्य कथयति द्युगुणम् ।
ध्व्यधिग्रहयोगाद् ग्रहांतराद्वा स कुटज्ञः ॥ २८ ॥

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२६. (घ) १. कलादिनाहताद्रुक्तात् (ग) कलादिना हृताद्रुक्तात् for (कलानाहताद्रुक्तात्)
(ग) (वि०—इसकी श्लोक संख्या २१ है।) २. (लब्धं भमंडल for (लब्धं मंडल)
(च) १. कलादिनाहताद्रुक्तात् for (कलानाहताद्रुक्तात्)
(ङ) (वि०—इसकी क्रम संख्या २१ है
४. निश्छेद for (निछेद) १. कलादिना for (कलाना)
३. हताद्रुक्तात् for (हताद्रुक्तात्)
५. दिनगणोऽस्मात् for (दिनगणोस्मात्)

२७. (घ) १. हर्गऽणः for (हर्गणः) २. छेषम् for (छेशषम्)
(ग) (वि—इसकी श्लोक संख्या २२ है।) ३. कलाविकला (ङ) for (कला)
४. शेषादहर्गणः (ङ) for (शेषाण्यहर्गणः)
(च) २. वछेषं for (वछेशषम्) १. हर्ग्गणः for (हर्गणः)
(ङ) (वि० इसकी क्रम संख्या २२ है)
५. नष्टस्थेष्विष्टान् for (नष्टस्थानेष्विष्टानं)
६. तान् for (कान्) ७. कृत्वा भक्त्वोक्त for (कृत्वोक्त)
२. वच्छेषम् for (वछेशषम्)

२८. (घ) १. द्युगणम् (ग) (च) (ङ) for (द्युगुणम्)
२. द्व्यादि for (ध्व्यधि) (ग) द्व्यादिग्रहसंयोगात् for (ध्व्यधिग्रहयोगाद्)
३. गुहांततरात् (ग) ग्रहांतरद्वा for (ग्रहांतराद्वा)
४. कुट्टकज्ञः (ग) for (कुटज्ञः)
(ग) (वि—इसकी श्लोक संख्या २० है परंतु लिखो हुई १० है।)
५. दृष्ट्वा (च) (ङ) for (द्रष्ट्वा)
(च) २. द्व्यादिग्रह for (ध्व्यधिग्रह) ४. कुट्टज्ञः for (कुटज्ञः)
(ङ) (वि०—इसकी क्रम संख्मा २० है)
२. द्व्यादिग्रह संयोगात् for (ध्व्यधिग्रहयोगाद्)
४. कुट्टज्ञः for (कुटज्ञः)

येन गुणे[१] शेषयुते[२] छेदः शुध्यति हृत[४] स्वगुणकेन ।
तद्भुक्तं[५] शेषं फलमेव[६] शेषाद्ग्रह[७]द्युगुणैः[३] ॥ २९ ॥
राश्यंशकला[३] विकला शेषात्कथितादभीष्टतोनष्टात्[७] ।
यः साधयद्युपरिमान[१] समध्यमा[४] कुदकज्ञः[२] स ॥ ३० ॥
इति श्री[५] कुट्टक[६] प्रकरणम्

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२९. (घ) १. गुण (ग) गुणः for (गुणे) २. युतछेद (ग) हृताछेदः for (युते छेदः)
३. गणैः (ग) गणौ for (गुणैः)

(ग) (वि०—इसकी श्लोक संख्या २४ है) ४. हृदः for (हृत)
५. न तदुक्तं for (तद्भुक्तं) ६. फलमेवं for (फलमेव)

(च) १. गुणों शेषयुतां for (गुणे शेषयुते)
४. हृतः for (हृत) ३. द्युगणैः for (द्युगुणैः)

(ङ) १. (वि०—इसकी क्रम संख्या २४ है)
१. गुणः for (गुणे) २. युतश्छेदः for (युते छेदः)
४. हृतः for (हृत) ७. शेषाद्ग्रह for (शेषाद्ग्रह)
३. द्युगणौ for द्युगुणैः)

३०. (घ) १. त्युपरिमान् (ग) त्युपरिधमान् for (द्युपरिमान्)
५. वि०—मूल में 'इति श्री' पद नहीं है ।
२. कुट्टकज्ञः (ग) for (कुदकज्ञः स)

(ग) (वि—इसकी श्लोक संख्या २३ है)
३. विकलांशशेषात् for (विकलाशेषात्)
४. समध्यमान् for (समध्यमा)

(च) १. साधयत्युपरिमान् for (साधयद्युपरिमान्)
४. समध्यमात् for (समध्यमा) ५. 'इति श्री' लुप्त
६. कुदक for (कुट्टक)

(ङ) (वि०—इसकी क्रमसंख्या २३ है)
७. नष्टान् for (नष्टात्) १. साधयत्युपरितनान् for (साधयद्युपरिमान्)
४. समध्यमान् for (समध्यमा)
२. कुट्टकज्ञः for (कुदकज्ञः) ५. 'इति - से—णम्' तक सब लुप्त ।

[५]अथ धनर्ण [१]श्रुत्यानां [६]संकलना

धनयोर्धन[८]मृणयोर्धन[७]र्णयोरंतरं [२]समैक्य[६]खं ।
[३]वर्णैक्य[१०]मृणं धनशून्ययोः [४]द्रूनं शून्ययोः शून्यम् ।। ३१ ।।
[१]ऋणमधिकाद् विशोध्यं धनं धनादृणमृणादधिकमूनात् ।
व्यस्तं तदंतरं [२]वा ऋणं [४]धनं न [३]मृणं भवति ।। ३२ ।।

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३१. (घ) १. शून्यानां for (श्रुत्यानां)
२. समैक्यं (ग) for (समैक्य)
३. खर्णैक्य (ग) स्वर्णैक्यमृण for (वर्णैक्यमृणं)
४. द्वूनं (ग) for (द्रूनं)

(ग) (वि०—इसकी श्लोक संख्या ३० है)
५. 'अथ' से 'संकलना' तक लुप्त है ।
६. स्वं for (खं)

(च) ५. अथधनर्ण्य for (अथधनर्ण)
१. शून्यानां संकलना: for (श्रुत्यानां सकलना)
७. धनर्ण्ययो for (धनर्णयो)
२. समैक्यं for (समैक्य)
३. खवर्ण्यैक्य for (वर्णैक्य)
४. द्वूनं for (द्रूनं)

(ङ) १. शून्यानां for (श्रुत्यानां)
४. "द्रूनं" लुप्त
६. सङ्कलनम् for (संकलना)
८.+मृण+
२. समैक्यं for (समैक्य)
३. ऋणमैक्यं च for (वर्णैक्य)
१. धनमृण for (मृणं)

३२. (घ) १. ऊन (ग) (च) (ङ) for (ऋण)
२. खादृणं (ग) (च) for (वा ऋणं)
३. 'ण' को लिखना भूल गया

(ग) (वि०—इसकी श्लोक संख्या ३१ है)
४. धनं धनमृणं भवति for (धनं न मृणभवति)

(च) ३. नमृभति for (न मृणभवति)

(ङ) २. स्यादृणं for (वा ऋणं)
३. धनमृणं for (नमृण)

शून्यविहीन[४]मृणमृणं धनं धनं भवति शून्यमाकाशम् ।
शोध्ये[५] यदा धनमृणादणं[१] धद्धा[२]तद[७]श्रे[३]य्यम्[६] ॥ ३३ ॥
प्रत्युत्पन्नः[७] ऋणमृणधनयोर्घाते[३] धनमृणयोर्[४]धँन[५] वधोधनं भवति ।
शून्यण्ययोः[१] स्वधनयोः[४] खशून्ययो र्वा वध[२] शून्यम्[६] ॥ ३४ ॥

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३३. (घ) १. दृणं (ग) (च) (ङ) for (दणं)

२. धनाद्वा (ग) (ङ) for (धद्धा)

३. क्षेप्यम् (ग) तदा क्षेप्यम् for (तदश्रेय्यम्)

(वि०—इसकी क्रमसंख्या ३४ लिखी है)

(ग) ४. विहिन for विहीन ५. शोध्यं (च) (ङ) for (शोध्ये)

(वि०—इसकी संख्या ३२ है)

(च) २. धट्वा for (धद्धा) ३. तदशेप्यं for (तदश्रेय्यम्)

(वि०—यहां क्रमसंख्या ३४ अंकित है)

(ङ) ७. तदा for (तद) ३. क्षेप्यम् for (श्रेय्यम्)

३४. (घ) १. शून्यर्णयोः (ग))ङ) for (शून्यण्योः)

२. वधः (ग) (च) (ङ) for (वध)

(वि०—इसका संख्याक्रम ३५ लिखा है।)

(ग) (वि०—इसकी श्लोक संख्या ३३ है, परन्तु 'प्रत्युतपन्न' यहां लुप्त है) (ङ)

ऋणमृणधनयोर्घातौ धनमृणयोर्धनवधो धनं भवति ।

शून्यर्णयोः खधनयोः खशून्ययोर्वा वधः शून्यम् ॥ ३३ ॥

३. घातो (ङ) for (र्घाते) ४. खधनयोः for (स्वधनयोः)

(च) ३. र्घातो for (र्घाते) ५. र्द्धन for (र्धन)

१. शून्यर्ण्ययोः for (शून्यण्योः)

५. (वि०—यहां क्रमसंख्या ३५ अंकित है)

(ङ) ७. 'प्रत्युत्पन्नः' लुप्त

धनभक्तं धनमृणहृतं[1] मृणं[3] धन[2] भवति खंखभक्तम्[5] ।
खंभक्तमृणे[5][6] धनधनमृणधनेन[7][3] हृतमृणमृणं[4][8] भवति ।। ३५[9] ।।

खोद्धृतमृणधनं[4] वा तच्छेदं[5] खमृणधन विभक्तं वा[1] ।
धनमृणधनयोर्वर्गः[6] खं[7] खस्यपदं[2] कृतियत्तत[3] ।। ३६ ।।

योगोन्तर युतहीनो[5] द्विहृतः[1] संक्रमणमंतरविभक्तम्[7] ।
वार्गान्तिरमंतर[2] युतहीनं द्विहृतं[3] विषमकर्म[4][2][6] ।। ३७ ।।

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३५. (घ) (वि०—इस श्लोक की दूसरी पंक्ति का आरंभिक 'ख' पहली पंक्ति का अंतिम शब्द है)
१. हृतमृणं (ग) (ङ) (च) for (हृतंमृणं)
२. धनं (ग) (च) (ङ) for (धन) ३. मृणं (ग) (च) (ङ) for (मृण)
४. हृत (ग) (च) (ङ) for (हृत)
(वि०—इसका संख्याक्रम ३६ लिखा है)
(ग) ५. भक्तं खम् । यहां 'खं' पहली पंक्ति का अंतिम पद है ।
दूसरी पंक्ति 'भक्त' से आरम्भ होती है । इसकी क्रमसंख्या ३४ है । (ङ)
६. मृणेन (ङ) for (भक्तमृणे) ७. 'धन' यह पद लुप्त है (ङ)
८. मृणधनं भवति for (मृणमृणं)
(च) १. यहां क्रमसंख्या '३६' अंकित है ।

३६. (घ) १. वाः for (वा)
(वि०—इसका संख्याक्रम ३७ लिखा है)
(ग) २. कृतिर्यक्रत् for (कृतियत्तत्)
(वि०—इसकी श्लोक संख्या ३५ है)
(च) ३. (वि०—यहाँ क्रमसंख्या ३७ अंकित है)
(ङ) ४. मृणं for (मृणं) ५. तच्छेदं for (तछेदं)
६. ऋणधनयो for (धनमृणधनयो)
७. स्वं खं for (खं) २. यत्तत् for (यत्तत)

३७. (घ) १. हृतः (ग) (च) (ङ) for (हृतः)
२. वर्गान्तर (ग) (च) (ङ) for (वार्गान्तर)
३. हृतं (ग) (च) (ङ) for (हृतं) ४. कर्म्मः (ग) (च) for (कर्म)
(वि०—इसका संख्याक्रम ३८ लिखा है)
(ग) ५. युतहिनो for (युतहीनो) (वि०—इसकी श्लोक संख्या ३६ है)
(च) ६. (वि०—यहां क्रमसंख्या ३८ अंकित है)
(ङ) ७. +वा+

करार्णलंबस्तत्कृति रिष्टहूतेष्टोन संयुतोऽल्पोभूः ।
अधिको द्विहृतो बाहु संक्षेप्यावद्वधो वर्गः ॥ ३८ ॥
इष्टोद्धृत कराणी पदक्रतियुतिरिष्टगुणितांतरकृतिर्वा गुण्यः ।
स्तिर्यगधोधो गुणकः समसद्गुणः सहितः ॥ ३९ ॥
सेष्टर्णछेदगुणो भाज्यछेदौ पृथक् युतावसकृत् ।
छेदैकगत हूतौर्द्धो भाज्यो वर्गः समद्विवधः ॥ ४० ॥

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३८. (घ) १. करणी (ग) (ङ) for (करार्ण)
२. हृतो (ग) (च) for (हृतो) ३. बाहू (ग) बाहुः (ङ) for बाहु
(वि०—इसका संख्याक्रम ३९ है ।)
(ग) ४. हृते (च) for (हूते) ५. संयुताल्पोभूः for (संयुतोऽल्पोभूः)
६. संक्षेप्या यद्वधो for (संक्षेप्यावद्वो)
(च) १. करणी for (करार्ण) ७. (यहां क्रमसंख्या ४९ अंकित है)
(ङ) ५. संयुताऽल्पा भूः for (संयुतोऽल्पोभूः) ६. संक्षेप्पो यद्वधो for (संक्षेप्यावद्वधो)

३९. (घ) १. करणी (ग) (च) (ङ) for (कराणी)
२. 'गुण्य' यह पद दूसरी पंक्ति के आरम्भ में है (ग)
(वि०—इसका संख्याक्रम ४० है)
(ग) ३. पदयूतिकृति for (पदक्रतियुति) २. गुणास्ति for (गुण्यः)
४. गुणक (ङ) for (गुणकः) ५. समस्तद्गुण सहितः ॥ ३८ ॥ for (समसद्गुणः सहितः ॥ ३९ ॥)
(च) २. र्वागुण्य for (र्वागुण्यः) ६. (यहां क्रमसंख्या ४० अंकित है)
(ङ) ३. पदयुतिकृति for (पदक्रतियुति) २. 'गुण्यः' दूसरी पंक्ति का आरम्भिक पद ।
५. समस्तद्गुणः for (समसद्गुणः)

४०. (घ) हृतो (ग) (च) (ङ) for (हूतौ)
२. समद्विवधः (ग) समिद्विविधः for (समद्विवधः)
(वि०—इसका संख्याक्रम ४१ है)
(ग) ३. गुणौ for (गुणो) ४. प्रथक् for (पृथक्) ५. वा भाज्यो (ङ) for (र्द्धोभाज्यो)
(वि०—इसकी क्रमसंख्या ३९ है) (ङ)
(च) ३. सेष्टर्ण्यछेदगुणो for (सेष्टर्णछेदगुणो) ६. भाद्यछेदौ for (भाज्यछेदौ)
५. र्द्धोभाद्यो for (र्द्धोभाज्यो) २. समद्विवधः for (समद्विवधः)
७. (वि०—यहां क्रमसंख्या ४१ अंकित है)
(ङ) ३. च्छेदगुणौ for (छेदगुणो) ७. युजावसकृत् for (युतावसकृत्)
२. समद्विवधः for (समद्विवधः)

इष्टकरन्यू[1]नाया रूपकृतैः[4] पदयु[5]तोनरूपार्द्धे ।
प्रथमे[2] रूपाण्यन्यहि[3]ना द्वितीयं[6] करण्यसकृत् ।। ४१ ।।[7]
अव्यक्तवर्गधनवर्ग[1]वर्ग[2] पंचगत[3]षड्गतादीनाम् ।
तुल्यानां संकलित[4] व्यवकलिते[5] पृथग[6]तुल्यानाम् ।। ४२ ।।[7]
सदृश द्विवधो[2] वर्गत्र्यादिवधस्तद्गतोऽन्यरूपवधः[3] ।
अन्योन्य[4]वर्ग[1]घातो भावितकः पूर्व[6]वच्छे[5]षम् ।। ४३ ।।

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४१. (घ) १. करण्यूनाया (ग) (च) (ङ) for (करन्यूनाया)
२. प्रथमं (ग) (ङ) for (प्रथमे) ३. द्विना (ग) द्वितिय for (हिना)
(वि०—इसका संख्याक्रम ४२ है)
(ग) ४. रूपकृते: (ङ) for (रूपकृतैः) ५. यूतो for (युतो)
६. 'द्वितीयं' लुप्त है
(वि०—इसकी श्लोक संख्या ४० है)
(च) ३. रूपाण्यन्यद्विना for (रूपाण्यन्यहिना)
(वि०—यहां क्रमसंख्या ४२ अंकित है)
(ङ) १. ण्यूनाया for (न्यूनाया) ३. त्ततो for (हिना)

४२. (घ) (वि०—इसका संख्याक्रम ४३ है।)
(ग) १. घनवर्ग (ङ) for (धनवर्ग) २. यहां एक 'वर्ग' लुप्त है।
३. गतः for (गत) ४. संकलिते for (सङ्कलित)
५. 'व्यवकलिते' लुप्त है
६. प्रथग for (पृथग)
(वि०—इसकी श्लोक संख्या ४१ है)
(च) ७. (वि०—यहां क्रमसंख्या ४३ अंकित है)
(ङ) (वि०—क्रमसंख्या ४१ है)

४३. (घ) (वि०—इसका संख्याक्रम ४४ है)
१. वर्गा (ग) (ङ) for (वर्ग)
(ग) २. द्विधो for (द्विवधो) ३. न्यवधः for (ऽन्यरूपवधः)
४. सन्योन्य for (अन्योन्य)
(वि०—इसकी श्लोकसंख्या ४२ है)
(च) १. वर्ण्य for (वर्ग)
५. (वि०—यहां क्रमसंख्या ४४ अंकित है)
(ङ) ३. ऽन्यजातिवधः for (ऽन्यरूपधः) ६. पूर्ववच्छेषम् for (पूर्ववछेषम्)

'इति धनर्णादीनां सङ्कलित व्यवकलितादि'

मंडलशेषाद्युनान्मूलं व्येकं दशाधृतं द्वियुतम् ।
मंडलशेषं व्येक भानोर्ज्ञदिने कदा भवति ॥ ५० ॥
अधिमास शेषपादा न्यूनाद्वर्गोधिमासशेषसमः ।
अवमावशेषतो वा वमवशेषसमः कदा भवति ॥ ५१ ॥
आद्याद्वर्णादन्यान् व्यस्तान्प्रोह्याद्यमानमाद्यहृतात् ।
सद्रशा छेदान् सकृत् द्वौ व्यस्तौ उदकोबप्पू ॥ ५२ ॥

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५०. (घ) (वि०—इसकी क्रमसंख्या ५१ है)
१. द्वयू (ग) द्युनामूलं for (द्युनान्मूलं)
२. हृतं (ग) हृतं for (धृतं) ३. व्येकं (ग) (ङ) for (व्येक)
(ग) . (वि०—इसकी श्लोक संख्या ४६ है)
(च) १. द्वयूनान् for (द्युनान्) २. हृतं for (धृतं)
४. (वि०—इसकी क्रमसंख्या ५१ अंकित है)
(ङ) १. द्वयूनान्मूलं for (द्युनान्मूलं) २. दशाहृतं for (दशाधृतं)

५१. (ग) (वि०—इसकी क्रमसंख्या ५२ है)
(ग) १. न्यूनाद्वर्गा for (न्यूनाद्वर्गो) २. यमः for (समः)
६. अमावशेषतो for (अवमावशेषतो) ४. 'व' लुप्त है (ङ)
(वि०—इसकी श्लोक संख्या ५० है)
(च) १. द्वर्गोऽधिमासशेषः for (द्वर्गोधिमासशेष)
५. (वि०—क्रमसंख्या ५२ अंकित है)
(ङ) ६. पादात् for (पादा) १. न्यूनाद्वर्गो for (न्यूनाद्वर्गो)

१. हृतात् (च) for हूतात्) २. सहस (ग) सहशा for (सद्रशा)
३. नसकृत (ग) for (नसकृत्)
४. कुट्टको (ग) (ङ) for (उदको) ५. बहुषु (ग) (ङ) for (बप्पू)
(वि०—इसकी श्लोक संख्या ५३ है)
(ग) (वि०—इसकी श्लोक संख्या ५१ है)
६. मद्य for (माद्य) ६. तत् for (तात्)
(च) २. सदृस for (सद्रशा) ३. नसकृत् for (नृसकृत्)
५. बप्पु for (वप्पू) (वि०—यहां श्लोक संख्या ५३ अंकित है)
(ङ) शीर्षक+इदानीमनेकवर्णसमीकरणमाह+
८. वर्णान् for (व्यस्तान्) २. सदृश for (सद्रशा)
१. हृतम् for (हूतात्) ३. च्छेदावसकृदद्वौ for (छेदान् सकृत्द्वौ)

गतभगणयुता द्यु गुणा तद्वेषयुता तदैक्ययुताद्वा ।
तद्योगाद्वा द्यु गुणो यः कथयति कुट्टक्ज्ञः सः ॥ ५३ ॥
गतभगणोना द्यु ना गणातच्छेषो ना तदैक्यहीनाद्वा ।
तद्विवराद्वा द्विगुणं यः कथयति कुट्टकज्ञः सः ॥ ५४ ॥

५३. (घ) १. गणात्त (ग) द्युगुणात् for (द्युगुणा)
२. छेष (ग) for (तद्वेष) २. त्तदैक्य (ग) for (तदैक्य)
४. गणं for (गुणो)
(वि०—इसकी क्रमसंख्या ५४ लिखी है)
५. गतभंगयुतात् for (गतभगणयुता)
६. संयुक्तात् (ङ) for (युताद्वा) ७. तद्योगाद्यु गुणं for (तद्योगाद्वाद्यु गुणो)
८. कुट्टकज्ञः (ङ) for (कुट्टक्ज्ञः)
(वि०—इसकी श्लोक संख्या ५२ है)
(च) १. द्यु गणा for (द्यु गुणा) २. त्तछेषयुता for (तद्वेषयुता)
६. युक्ताद्वा for (युताद्वा) ७. ताद्योगाद्वा for (तद्योगाद्वा)
४. द्यु गणं for (द्यु गुणो) ८. कुदकज्ञ for (कुट्टक्ज्ञः)
१. (वि०—यहां श्लोक संख्या ६४ अंकित है)
(ङ) ५. भगणयुताद् for (भगणयुता) १. द्युगणात् for (द्यु गुणा)
२. तच्छेषयुतात् for (तद्वेषयुता)
४. द्यु गणं वा for (वा द्यु गुणो)

५४. (घ) (वि०—इसकी क्रमसंख्या ५५ है)
१. द्यु गणात्त (ग) द्युगणात्त्त for (द्युनागणा)
२. छोषानात्तदैक्य (ग) छेशोना for (छेषोना)
(ग) ३. नात् (ङ) नाद् for (ना) ४. तद्विवराद्युगणं for (तद्विवराद्वा)
(वि०—इसकी श्लोकसंख्या ५३ है)

राश्याद्यैस्त छेशैश्चैवं भुक्ताधिमास हीनदिनैं ।
तच्छेषैश्चयुगगतं य कथयति कुट्टकज्ञः सः ॥५४॥

(ङ) १. दिनहीनैः for (हीनदिनैः) २. तच्छेषैश्च for (तच्छेषैश्च)
(च) १. द्यु गणा for (द्यु नागणा) ५. त्तदैक्य for (तदैक्य)
६. कुदकज्ञ for (कुट्टकज्ञ) ७. (वि०—यहां क्रमसंख्या ५५ अंकित है)
(ङ) ३. द्युगणात् for (द्यु नागणा) २. तच्छेषोनात् for (तच्छेषोन)
४. द्युगणं वा for (वाद्विगुणं)

अंशक शेषेण युता[५] स्त्रिप्ता[१] शेषात्र[२] तदंतरादथवा ।
भानोर्ज्ञदिने द्यु[३]गुणं यः कथयति कुटकज्ञः[४] सः ।। ५५[१] ।।
अंशक शेष[२] त्रियुतं लिप्ता शेषं कदा रवेर्ज्ञ दिने षट्[३] ।
सप्ताष्टोन[४] वा[१] कुर्वन्नावत्सराद्गणकः ।। ५६[५] ।।
अंशसम[६] मंशके[१] कलासमं[७] वा कला[२] कदा[३] शेषम् ।
दिवसकर[४]स्येष्ट दिने कुर्वन्नावत्सराद्[५]गणकः ।। ५७ ।।

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५५. (घ) (वि०—इसकी क्रमसंख्या ५६ है)
१. लिप्ता (ग) (च) for (स्त्रिप्ता) ३. द्युगणं (च)(ङ) for (द्युगुणं)
२. शेषात्तदंतरा (ग) (च) for (शेषात्रतदंतरा)
४. कुट्टकज्ञ (ग) कुट्टकज्ञः for (कुटकज्ञः)
(ग) ५. हृता for (युता) (वि०—इसकी श्लोक संख्या ५५ है)
(च) ४. कुदकज्ञः for (कुटकज्ञः) (वि०—इसकी क्रमसंख्या ५६ अंकित है)
(ङ) ५. युतात् for (युता) लिप्ता for (स्त्रिप्ता)
२. शेषात् for (शेषात्र)
५६. (घ) (वि०—इसकी क्रमसंख्या ५७ है) १. नं वा (ग) नावां for (नवा)
(ग) २. शेषं (ङ) for (शेष)
३. 'षट्' दूसरी पंक्ति का प्रथम पद है (ङ)
४. सप्तष्टौ for (सप्ताष्टो)
(वि०—इसकी श्लोकसंख्या ५६ है)
(च) १. सप्ताष्टोनं for (सप्ताष्टोन)
५. (वि०—इसकी क्रमसंख्या ५७ अंकित है)
(ङ) १. नव वा for (न वा) ४. सप्ताष्टौ for (सप्ताष्टो)
५७. (घ) (वि०—इसकी क्रमसंख्या ५८ है)
१. मंशाशकला for (मंशके) २. कदा (ग) for (कला)
६. कला (ग) for (कदा) ४. दिवसरस्येष्ट for (दिवसकरस्येष्ट)
५. त्स्थराद्गणकः for (त्सराद्गणकः)
(ग) ६. अंशयुगमंशशेषं for (अंशसममंशके) ७. कलासमांश for (कलासमं)
(वि०—इसकी क्रमसंख्या ५८ है, संख्या ५७ अंकित करना भूल गया)
(च) १. मंशशे for (मंशके) २. ३. कदा कलाशेषं for (कलाकदाशेषम्)
४. दिवसरस्येष्ट दिने for (दिवसकरस्येष्ट दिने)
५. स्थराद्गणकः for (सराद्गणकः)
(ङ) १. मंशशेषं for (मंशके) ३. 'कदा' लुप्त

अवमावशेषमवमैरधिमासकशेषमधिकमासैर्वा[3] ।
इष्टयुतोनं तुल्यं कुर्वन्नावत्सर[1]गणकः ।। ५८[2] ।।
निछेद[3] भागहारो[1] भानो[4] सप्ततिगुणोंशशेषोनः[2] ।
शुध्यत्ययुत विभक्तः कुर्वन्नावत्सराद्गणकः ।। ५९[5] ।।
भावितकरूप गुणना साव्यक्तवधेष्टभाजिताप्वासौ[1] ।
अल्पाधिके[2] धिकोल्पेक्षेप्यौ[3] भावितहूतौ[4] व्यस्तौ[5] ।। ६०[6] ।।

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५८ (घ) (वि०—इसकी क्रमसंख्या ५९ है)
१. सराद्गणकः for (सरगणकः)

(च) १. सद्गणकः for (सरगणकः)
२. (वि०—यहां क्रमसंख्या ५९ अंकित है) ३. र्वाः for (र्वा)

(ङ) ३. मधिमासैः for (मधिकमासैर्वा) १. सराद्गणकः for (सरगणकः)

५९. (घ) (वि०—इसकी क्रमसंख्या ६० है)
१. भागहारो (ङ) (मागहारो) २. गुणोऽंश for (गुणोंश)

(ग) ३. निश्छेद (ङ) for (निछेद) ४. भानोः (च) (ङ) for (भानोः)
(वि०—क्रमसंख्या ५९ है)

(च) २. गुणोऽंशशोषोनः for (गुणोंशशेषो नः)
(वि०—क्रमसंख्या ६० अंकित है)

६० (घ) (वि० – इस श्लोक की क्रमसंख्या ६१ है)
१. भाजितेऽष्टयाप्तौ (ग) भाजितेष्टाप्त्योः (ङ) for (भाजिताप्वासौ)
२. अल्पऽधिकोऽधिको (ग) अल्पेऽधिकल्पः for (अल्पाधिकोधिकोल्पे)
३. थौ (ग) क्षेप्यो for (क्षेप्यौ) ४. हृतौ (च) (ङ) for (हूतौ)

(ग) ५. व्यस्तम् (ङ) for (व्यस्तौ)

(च) १ भाजिष्टयाप्तौ for (भाजिताप्वासौ)
६. (वि०—यहां क्रमसंख्या ६१ अंकित है)

(ङ) शीर्षक—+अथ भावितबीजम्+
२. अल्पेऽधिकोऽधिकेऽल्पः for (अल्पाधिकोधिकोल्पे)
३. क्षेप्या for (क्षेप्यौ)

भानोराश्य शवधा[२] त्रिचतुर्गुणितान्विशोध्यराश्यंशात्[३] ।
नवति[१] द्रष्ट्वा[४] सूर्यं कुर्वन्नावत्सराद्गणकः ॥ ६१[५] ॥
भावितके[३] तद्घातो[६] विनष्ट[१] वर्णेन तत्प्रमाणानि ।
ऋत्वेष्टानि[२] तदाहृत वर्णैक्यं[४] भवति रूपाणि ॥ ६२[५] ॥
वर्णप्रमाणभावितघातो[४] भवतीष्ट[१]वर्णसंख्यैवम्[२] ।
सिध्यति विनापि भावित[३]समकरणात् किंकृतं तदतः ॥ ६३[५] ॥
मूल[१]द्विधेष्ट[६]वर्गागुण[२]गुणादियुत[७]विहीनाच्च[८] ।
आध्यवधो[३] गुणक गुणः[९] संहांत्पवातेन[४] पमत्यम्[५] ॥ ६४[१०] ॥

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६१. (घ) (वि० इस श्लोक की क्रमसंख्या ६२ है) १. नर्वात (ग) नर्ति for (नवति)
(ग) २. वधात्रि (ङ) for (वधात्रि) ३. राश्यंशान् for (राश्यंशात्)
(च) १. नर्वति for (नवति) ४. दृष्ट्वा (ङ) for (द्रष्ट्वा)
५. (वि०—यहां क्रमसंख्या ६२ अंकित है) (ङ) १. नर्वति for (नवति)

६२. (घ) (वि०—इसकी श्लोकसंख्या ६३ है) १. विनष्टे (च) for (विनष्ट)
२. कृत्वेष्टानि (ग) (च) (ङ) for (ऋत्वेष्टानि)
(ग) ३. भाविक यद्घातो for (भावितके तद्घातो)
(च) ५. (वि०—इसकी क्रमसंख्या ६३ अंकित है)
(ङ) ६. यद्घातो for (तद्घातो)

६३. (घ) (वि०—इसकी क्रमसंख्या ६४ है)
(ग) १. भवतिष्ट for (भवतीष्ट) २. संख्यैक्यम् for (संख्यैवम्) ३. काम for (सम)
(च) ४. द्यातो for (घातो) ५. (वि० इसकी क्रमसंख्या ६४ अंकित है)

६४. (घ) (वि०—इस श्लोक की क्रम संख्या ६५ है)
१. मूलं (ग) for (मूल) २. वर्गाद्गुण (ग) वर्गात् गुणक for (वर्गागुण)
३. आद्य (ग) (च) (ङ) for (आध्यवधो)
४. सहांत्यघातेन (ग) संहृत्य घातेन for (संहात्पवातेन)
५. पमंत्यम् (ग) मन्त्यम् for (पमत्यम्)
(ग) ६. द्विधेष्ठ for (द्विधेष्ट) ७. गुणादिष्टयुत for (गुणादियुत)
८. विहिनाच्च for (विहीनाच्च) ९. गुण for (गुणः)
(च) २. वर्गाद्गुण for (वर्गागुण) ४. सहांत्यघातेन for (संहांत्यवातेन)
५. पमंत्ययं for (पमत्यम्) १०. (वि०—इसकी क्रम संख्या ६५ अंकित है)
(ङ) श्री —+अथ वर्ग प्रकृतिः+
२. वर्गाद् गुणक for (वर्गागुण) ७. गुणादिष्ट for (गुणादि)
४. सहान्त्यघातेन for (संहांत्पवातेन) ५. कृतमन्त्यम् for (पमत्यम्)

वज्रावधैक्यं प्रथमं प्रक्षेपः क्षेप्य शोध्यतुल्यवधः ।
प्रक्षेपशोधकहृते मूले प्रक्षेपके रूपे ।। ६५ ।।
रूपप्रक्षेपपदे पृथगीष्टक्षेप्यशोध्यमूलाभ्याम् ।
कृत्वाद्योत्पाद्यपदे प्रक्षेपे शोधने वेष्ट चतुरधिके ।। ६६ ।।
इत्यपदकृतिस्त्र्यूना दलितांत्य पदगुणात्पदम् ।
अंत्यपदकृतिर्व्येका द्विहृताद्यपदा हृताद्यपदम् ।। ६७ ।।

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६५. (घ) (वि०—इस श्लोक की क्रम संख्या ६६ है)
१. वज्रवधैक्यं (ग) वज्रमधैक्यं for (वज्रावाधेक्यं)
२. हृते (ग) तुहृते for (हृते)
(ग) ३. 'शोध्य' पद लुप्त है।
(च) १. वज्रवाधेक्यं for (वज्रावाधेक्यं)
२. हृते for (हृते) ४. (वि०—यहाँ क्रमसंख्या ६६ अंकित है।)
(ङ) १. वजवधैक्यं for (वज्रावाधेक्यं)
३. क्षेपवधतुल्यः for (क्षेप्यशोध्यतुल्यवधः) २. हृते for (हृते)

६६. (घ) (वि०—इस श्लोक की क्रम संख्या ६७ है)
१. पृथगिष्ट (ग) (च) (ङ) for (पृथगीष्ट)
२. ऽद्योत्पाद्य (ग) कृत्वाद्यांशाद्य पदे for (कृत्वाद्योत्पाद्यपदे)
(ग) ३. रूपं for (रूप) ४. 'क्षेप्य' पद लुप्त है।
५. वेष्टे (यहाँ श्लोक समाप्त है), 'चतुरधिके' ६७ वें श्लोक का आरंभ है।
(च) ४. रूपप्रक्षेपदे for (रूपप्रक्षेपपदे) २. ऽद्योत्पाद्य for (घोत्पाद्य)
५. वेष्टे for (वेष्ट) ६. रधिकें for (रधिके)
(ङ) २. कृत्वाऽन्त्याद्यपदे for (कृत्वाद्योत्पाद्यपदे)
७. +ये+ ५. वेष्टे for (वेष्ट) ६. "चतुरधिके" लुप्त

६७. (घ) (वि०—इसकी श्लोक संख्या ६७ है)
१. गुणांत्यपदं (ग) for (गुणात्पदम्)
२. व्यंका (च) (ङ) for (व्येका) ३. हृता (ग) (च) (ङ) for (हृता)
(ग) ४. चतुरधिकेत्य for (इत्य) ५. पदं for (पद)
६. पादा for (पदा)
(च) ६. स्त्र्यिना for (स्त्र्यूना) १. गुणांत्यपदं for (गुणात्पदं)
७. व्यंका for (व्येका) ८. (वि०—क्रमसंख्या ६८ अंकित हैं)
(ङ) ४. चतुरधिकेऽन्त्य for (इत्य) १. गुणाऽन्त्यपदम् for (गुणात्पदम्)

चतुरूनैंत्यपद कृताग्रेकयुतेवधदलं प्रथग्वेकम् ।
व्येकाध्व्यहृतमंत्यं पदवधगुण मन्यदाद्यहृदम् ॥ ६८ ॥
वग गुणकः क्षेप; केनचिदुद्धृत युतोन को दलितः ।
प्रथमोंत्ये मूलमन्यो गुणरपदोद्धृत प्रथमम् ॥ ६९ ॥
गुणके वर्गछिन्ने छेदपदे यो धृतपदं प्रथमवर्गः ।
छेत्रे क्षेपे तन्मूले छेदपद गुणिते ॥ ७० ॥

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६८. (घ) (वि०—इसकी श्लोक संख्या ६९ है) १. त्र्येक for (अ्रेक)
२. पृथग् (ग) for (प्रथग्) (च) ३. द्याह (ग) (ङ) for (ध्व्यह)
(ग) ४. चतुरूनोंत्यपदकृतित्येकयुते for (चतुरूनैंत्यपदकृता अ्रेकयुते)
५. मन्यथाद्यपदम् for (मन्यदाद्यपदम्)
(च) १. त्र्येकयुते for (अ्रेकयुते) ३. द्याहृत for (ध्व्यहृत)
(ङ) ७. कृती for (कृता) १. त्र्येकयुते for (अ्रेकयुते)
२. पृथग्यव्येकम् for (प्रथग्वेकस्) ५. माद्यमान्त्य for (मन्यदाद्य)

६९. (घ) (वि०—क्रम संख्या ७० है) १. गुणाकार (ग) (ङ) for (गुणर)
२. पदोद्धृतः प्रथमम् (ग) धृतप्रथमः for (पदोद्धृत प्रथमम्)
(ग) ३. वर्गेण for (वर्गे) ४ गुणके (च) (ङ) for (गुणकः)
५. दुद्धृतो नितोदलतः for (दुद्धृ तयुतोनको दलितः)
६. प्रथमोंत्य (ङ) for (प्रथमोंत्ये)
(च) २. पदोद्धृतः for (पदोद्धृत) ७. (वि०—क्रम संख्या ७० अंकित है)
(ङ) ७. युतोनितोदलितः for (युतोनको दलितः)
२. पदोद्धृतः प्रथमः for (पदोद्धृत प्रथमम्)

७०. (घ) (वि०—इसकी क्रमसंख्या ७१ है)
१. धृतं for (धृतपदं) २. प्रथमं for (प्रथम)
३. 'वर्ग' (यह शब्द दूसरी पंक्ति का आरंभिक पद है) ४. छिन्ने for (क्षेत्रे)
(च) ६. वर्गछेान्ने for (वर्गछिन्ने) १. द्धृतपदं for (धृतपदं)
३. वर्ग for (वर्गः) ४. छेन्ने for (छेत्रे)
७. (वि०—यहाँ क्रम संख्या ७१ अंकित है)
(ङ) 'वर्गच्छिन्ने गुणके प्रथमं तन्मूलभाजितं भवति ।
वर्गच्छिन्ने क्षेपे तत्पदगुणिते तदा मूले ॥ ७० ॥
for
गुणके वर्गच्छिन्ने छेदपदे यो धृतपदं प्रथमवर्गः ।
क्षेत्रे क्षेपे तन्मूले छेद पद गुणिते ॥ ७० ॥

शशिलिप्ता शेषकृतिद्विनवति गुणिता अशिति गुणितं वा ।
सैकाङ्ग दिने वर्गं कुर्वन्नावङ्पराद् गणकः ।। ७१ ।।
इष्टभगणादि शेषं द्विनवत्यूनं त्र्यशिति संगुणितम् ।
रुपेण युतेन वर्गं कुर्वन्नावत्सराद् गणकः ।। ७२ ।।
भगणादिशेषवर्गं चतुर्गुणं पंचषष्टिसंयुक्तम् ।
षष्ट्यूनं वा वर्गं कुर्वन्नावत्सराद् गणकः ।। ७३ ।।

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७१. (घ) १. कृतिः (ग) कृति for (कृति) (वि०—इसकी क्रम संख्या ७२ है)
२. अशीति (ग) त्र्यशीति for (अशिति) ३. गुणितां for (गुणितं)
४. कुर्वन्नावत्सराद्गणकः (ग) for (कुर्वन्नावङ्पराद्गणकः)
(ग) ५. द्विनवगुणितं for (द्विनवतिगुणिता) ६. सैकं for (सैक)
७. वर्गे for (वर्गं)
वि०—इसके आगे "गुणितं वा । सैकंङ्ग दिने वग्र कुर्वन्ना० ।। ७५ ।।" लिखा है ।
(च) १. कृतिः for (कृति) ५. द्विनवति गुणितां for (द्विनवतिगुणिना)
२. अशीति for (अशिति) ३. गुणितां वा for (गुणितं वा)
४. कुर्वन्नावत्सराद्गणकः for (कुर्वन्नावङ्पराद्गणकः)
८. (वि०—यहाँ क्रमसंख्या ७२ अंकित है)
(ङ) वि यह श्लोक इस प्रति में उपलब्ध नहीं है ।

७२. (घ) (वि०—इसकी क्रमसंख्या ७३ है)
१. त्र्यशीति (ग) त्र्यशीति for (त्र्यशिति)
२. युतं (ग) (ङ) for (युतेन)
(ग) ३. वग्रं for (वर्गं) (वि०—इसकी श्लोकसंख्या ७७ है)
(च) १. त्र्यशीति for (त्र्यशिति) २. युतं for युतेन
४. (वि०—क्रम संख्या ७३ अंकित है)
(ङ) १. त्र्यशीति for (त्र्यशिति)

७३. (घ) (वि०—इसकी क्रम संख्या ७४ है)
यह श्लोक १९०२ में बनारस से मुद्रित प्रति में ७८ संख्या पर है
(ग) (वि०—यह श्लोक 'ग' में उपलब्ध नहीं है)
(च) (वि०—क्रमसंख्या ७४ अंकित है)
(ङ) (वि०—इसकी क्रमसंख्या ७८ अंकित है)

भगणादिशेष वर्गं त्रिभिर्गुणं संयुतं शतैर्नवभिः[1] ।
वर्गोष्टशतोनं[3] वा कुर्वन्नावत्सराद् गणकः ।। ७४[2] ।।
अधिमासशेषवर्गं[3] त्र्योदशगुणं[1] त्रिभिर्युक्तम्[4] ।
त्रिघनोनं वा वर्गं[5] कुर्वन्नात्सराद्[2] गणकः ।। ७५[6] ।।
अवमावशेषवर्गं द्वादशगुणितं शतेन संयुक्तम् ।
त्रिभिरूनं वा वर्गं कुर्वन्नावत्सराद् गणकः ।। ७६[1] ।।

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७४. (घ) (वि०—इसकी क्रमसंख्या ७५ है)

(ग) १. शनैन्नवभिः for (शतैर्नवभिः)
(वि०—इसकी क्रमसंख्या ७८ है)

(च) २. (वि०—क्रमसंख्या ७५ अंकित है)

(ङ) ३. कृतिमष्ट for (वर्गोष्ट)

७५. (घ) (वि०—इसकी क्रमसंख्या ७६ है)
१. त्रयोदश (ग) for (त्र्योदश) २. कुर्वन्नावत् (ग) (ङ) for (कुर्वन्नात्)

(ग) ३. वग्रं for (वर्गं) ४. त्रिभिः शतैर्युक्तम् (ङ) for (त्रिभिर्युक्तम्)
५. वग्रं for (वर्गं)
(वि०—इसकी क्रमसंख्या ७९ है)

(च) १. त्रयोदश (ङ) for (त्र्योदश)
६. (वि०—यहां क्रमसंख्या ७६ अंकित है)

७६. (घ) (वि०—इसकी क्रमसंख्या ७७ है)

(च) (वि०—इसकी क्रमसंख्या ७७ है)

(ङ) (वि०—इसकी क्रमसंख्या ८२ है)

(ग) (वि०—इसकी क्रमसंख्या ८० है)

७६. संख्या पर अंकित निम्नांकित अतिरिक्त श्लोक है—

सूर्यादि विलिप्ताशेषं पंचभिरूनादुगतं तथा दशभिः ।
वर्ग्रो बृहस्पति दिने कुर्वन्नावत्सराद् गणकः ।। ७६ ।।

(वि०—यह श्लोक इस प्रति में क्रमसंख्या ७६ पर है)
१. सूर्य for (सूर्यादि) २. रूनाहतं for (रूनादुगतं)
३. वर्ग for (वर्ग्रो)

गुणकयुतिरष्टगुणिता गुणिकांतरवर्गभाजिता राशिः ।
गुणकौ त्रिगुणौ व्यस्ताधिकौ हृतावंतरेण पदे ॥ ७७ ॥
इन्दुविलिप्ताशेषं सप्तदशगुणं च यो दशगुणं च ।
पृथगेयुतं वर्गं कुर्वन्नावत्सराद् गणकः ॥ ७८ ॥
वर्गोनकृतियुतो नानगास्तत्संयोतंराद्धकृतिभक्तः ।
तद्गुणकौ युतिवियुतौ वर्गो घाते च रूपयुते ॥ ७९ ॥

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७७ (घ) (वि०—इसकी क्रमसंख्या ७८ है)
१. गुणकांतर (ग) (ङ) (च) for (गुणिकांतर)
३. हृतावतरेण (ग) हृतावंतरेण (च) (हृतावंतरेण)
(ग) (वि०—यह श्लोकसंख्या इस प्रति में ७० पर, तथा बनारस में मुद्रित प्रति में ७१ पर अंकित है)
(च) (वि०—यहां क्रमसंख्या ७८ अंकित है)
(ङ) (वि०—इसकी क्रमसंख्या ७१ है)

७८. (घ) (वि०—इसकी क्रमसंख्या ७६ है)
१. त्रयोदशं for (चयोदश) (ग) 'च'से 'च' तक लुप्त
(ग) ३. गुणितं वा for (गुणं च) ३. पृथगेक (ङ) for (पृथगे)
(वि०—इसकी क्रमसंख्या ८१ है)
(च) १. त्रयोदश (ङ) for (चयोदश)
४. (वि०—क्रमसंख्या ७६ अंकित है)
(ङ) ५. चापि for (च)

७६.(घ) (वि०—इसकी क्रमसंख्या ८० है)
१. नगांस्तत्सांयातराद्धं (ग) नस्तत् संयोगांतराद्धं for (नानगास्तत्संयोतराद्धं)
(ग) २. न्यकृति for (नकृति) ३. कृतिर्भक्तः for (कृतिभक्तः)
४. तद्गुणितौ (ङ) for (तद्गुणकौ)
(च) २. वर्गोन्यकृति for (वर्गोनकृति)
१. नगांस्तत्संयोतराद्धं for (नानगास्तत्संयोतराद्धं)
४. तद्गुणको for (तद्गुणकौ)
५. (वि०—यहां क्रमसंख्या ८० है)
(ङ) (वि०—इसकी क्रमसंख्या ७२ है)
२. वर्गोऽन्यकृति for (वर्गोनकृति) १. नस्तत् for (नानगास्तत्)
५. वर्गौ for (वर्गो) ६. संयोगान्तरार्धं for (संयोंतराद्धं)

यैरूनो यैश्चयुतो रूपै[1]र्वर्गस्तदैक्यमिष्ट[2]हृतम् ।
इष्टोनं तद्दलकृतिरूनाभ्यधिका [3]भवन्ति [4]राशिः ।। ८० ।।[5]
याम्यां कृतिरधिकोनस्तदंतरं [3]हृतयुतो न [4]मिष्टेन ।
तद्दलकृतिरधिके[1] [5]न्यूनाभ्यधि [6]भवति [2]राशि ।। ८१ ।।[7]
[1]ज्ञदिनेऽर्के कलाशेषं गुरू [2]दिनविकलावशेष युक्तोनम् ।
[3]वर्गोविधं च सैकं कुर्वन्नावत्सराद् [4]गणकः ।। ८२ ।।

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८०. (घ) (वि०—इसकी क्रमसंख्या ८१ है)
१. वेर्गं (ग) (ङ) for (वर्ग) २. हृतं (ग) (ङ) for (हृतम्)
३. भवति (ग) (च) (ङ) for (भवन्ति)
४, राशिम् (च) for (राशिः)
(ग) (वि०—इसकी क्रमसंख्या ७२ है)
(च) १. वेर्गस्तदैक्य for (वर्गस्तदैक्य) ५. (वि०—इसकी क्रमसंख्या ८१ अंकित है)
(ङ) (वि०—इसकी क्रमसंख्या ७३ है) १. वेर्गस् for (वर्गस्)

८१. (घ) १. रधिकेन for (रधिके) (वि०— इसकी क्रमसंख्या ८२ है)
२. राशिः (ग) (च) (ग) for (राशि)
(ग) १. रधिकोना धिकयोरधिकोनयो राशिः for (रधिके न्यूनाभ्यधि भवति राशि)
३. हृत (ङ) (च) for (हृत) ४. मीष्टेन for (मिष्टेन)
५. ६. 'न्यूनाभ्यधि' 'भवति' पद लुप्त हैं ।
(च) १. रधिकेन for (रधिके) ५. न्यूनाभ्यधिका for (न्यूनाभ्यधि)
७. (वि०—क्रमसंख्या ८२ अंकित है)
(ङ) १. रधिकोना for (रधिके)
५. ऽधिकयोरधिको for (न्यूनाभ्यधि) ६. नयो for (भवति)

८२. (घ) (वि० इसकी क्रमसंख्या ८३ है)
(ग) (वि०—इसकी क्रमसंख्या ८२ है)
१. ज्ञदिनेर्कं for (ज्ञदिनेऽर्के) २. दिने for (दिन)
३. वर्ग्र धन for (वर्गोविधं)
(च) १. ज्ञदिनेर्क्क for (ज्ञदिनेऽर्के) २. दिनविवला for (दिनविकला)
३. वर्गोवधं for (वर्गोविधं) ४. (वि०—क्रमसंख्या ८३ अंकित है)
(ङ) (वि०— इसकी क्रमसंख्या ८३ है)
३. वर्ग वधं च for (वर्गो विधंच)

विकलाशेषं[३] सहितं त्रिवत्या[१]ऽ३ सप्तषष्टि[२]हीनं च
भानोर्ज्ञदिने वर्गं कुर्वन्नावत्सराद् गणकः ॥ ८३[४] ॥
ज्ञदिने[१]ऽर्कं क[२]लाशेषं वर्गो[३] द्वादशभिः संयुतं त्रिषष्ट्या च ।
षष्ट्याष्टाभिश्चोनं कुर्वन्नावत्सराद् गणकः ॥ ८४[५] ॥
इन्दु[२] विलिप्ता[५] शेषं[१] मंत्राशेषं वा ।
अथवा मध्य[३]मिष्टं कुर्वन्नावत्सराद् गणकः ॥ ८५[४] ॥
जीवविलि[२]प्ता शेषा कुजमिंदु[३] भौमलिप्तिकाशेषात् ।
रविर्मि[१]दभागशेषा[४] कु[५]र्वन्नावत्सराद् गणकः ॥ ८६[६] ॥

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८३. (घ) (वि०—इसकी क्रमसंख्या ८४ है)
१. ६३ (च) for (ऽ३) २. +६७+(च)
(ग) ३. शेषसहितं for (शेषं सहितं)
(च) ४. (वि०—क्रमसंख्या ८४ अंकित है)
(ङ) १. 'ऽ३' लुप्त ।

८४. (घ) (वि०—इसकी क्रमसंख्या ८५ है)
(ग) १. २. 'ऽर्ककला' पद लुप्त है । ३. वग्र्ग for (वर्गो)
(च) १. ऽर्क्क for (ऽर्क) ४. (वि०—क्रमसंख्या ८५ अंकित है)
(ङ) ३. 'वर्गो' (लुप्त)

८५. (घ) (वि०—इसकी क्रमसंख्या ८६ है)
१. शेषामंशशेषं वा (ग) शेषाद्रविलिप्ताशेषमंशशेषं वा for (शेषं मंत्राशेषं वा)
(ग) २. इदं for (इंदु)
(च) १. शेषामंशशेषं वा for (शेषं मंत्राशेषं वा)
३. मध्यममिष्टं for (मध्यमिष्टं) ४. (वि०—यहां क्रमसंख्या ८६ अंकित है)
(ङ) ५. +शेषाद् रविलिप्ता+ १. शेषमंशशेषं for (शेषं मंत्राशेषं)
३. मध्यममिष्टं for (मध्यमिष्टं)

८६. (घ) (वि०—इसकी क्रमसंख्या ८७ है)
१. मिंदु (ग) (ङ) for (मिंद)
(ग) २. जीवविप्ताशेषं for (जीवविलिप्ताशेषा)
३. विलिप्तिका for (लिप्तिका) ४. शेषात् (ङ) for (शेषा)
(च) १. द्रविर्मिदुभाग for (रविर्मिदभाग)
५. कुर्वन्नोवत्सराद्गणकः for (कुर्वन्नावत्सराद्गणकः)
७. (वि०—क्रमसंख्या ८७ अंकित है)
(ङ) २. विलिप्ताशेषात् for (विलिप्ताशेषा)

इष्टग्रहेष्टशेषा[५] द्यु गणो गतनिरपवर्त[२]यं[१] सं[३]गुणितैः ।
छेददिनैरधिकोस्मादन्यग्रहशेषमिष्टो वा ॥ ८७ ॥[४]
नि[७]छेदभागहारौ ग्रहयो[८]र्भगणादि शेषयो[३]द्यु[१]गुणात् ।
[४]यस्मात्तं नि[६]छेदेनो[२]द्धृतयो[५]र्लब्धयोर्गुणितौ ॥ ८८ ॥[६]
[६]निछेदभागहारौ विपरीतौ तद्यु ताा[१]त्फलस्तस्मात् ।
[४]शेषे[२]द्यु गुणादेवं [३]त्र्यादिना प्राग्वदिष्टदिने[५] ॥ ८९ ॥

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८७. (घ) (वि०—इसकी क्रमसंख्या ८८ है)
१. 'यं' यह मूलपाठ में उपलब्ध नहीं (ग)
(ग) २. निरवर्त्त for (निरपवर्तयं) ३. सं गुणतैः for (स गुणितैः)
(च) २.निरपवर्त्तस गुणितैः for (निपर्वर्तयं स गुणितैः)
४. (वि०—क्रमस ख्या ८८ है)
(ङ) ५. शेषाद् for (शेषा)
८८. (घ) (वि०—इसकी क्रमस ख्या ८९ है)
१. र्कगणात् for (र्द्युगुणात्) २. द्धृ तयो (ग) धृताया for (द्धृतयो)
(ग) ३. शेषवो द्युगणात् for (शेषयोद्यु गणात्)
४. यस्मात्तन्न for (यस्मात्तं)
५. लब्धस गुणितौ for (र्लब्धयोर्गुणितौ)
(च) १. र्द्युगणात् (ङ) for (र्द्युगुणात्) २. नोद्धृ तयो for (नोद्धृतयो)
६. (वि०— क्रमसंख्या ८९ अंकित है)
(ङ) ७. निश्छेद for (निछेद) १. निश्छेदे for (निछेदे)
८. विपरीतौ for (भंगणादि)
५. र्लब्धस गुणितौ for (र्लब्धयोर्गुणितौ)
३. ग्रहयो for (शेषयो)
८९. (घ) (वि०—इसकी क्रमस ख्या ९० है)
१. पुन (ग) पुनः शेषे for (फलस्तस्मात्)
२. द्युगणादेवं (च) (ङ) for (द्यु गुणादेव)
३. त्र्यादीनां (ग) (ङ) for (त्र्यादिना)
४. ३ द्यु गणादैवत्यादीनां for (शेषेद्यु गुणादेव त्र्यादिना)
(ग) (वि०—दूसरी पंक्ति "द्यु गणा" से आरम्भ होती है)
(च) १. पुनस्तस्मात् (ङ) for (फलस्तस्मात्)
५. (वि०— क्रमस ख्या ९० अंकित है)
(ङ) ६. निश्छेद for (निछेद)

द्यु[1]गुणमवशेषाद्रविचंद्रौ[2] मध्यमौ स्फुटादथवा[3] ।
एवं तिथिं ग्रहं वा कुर्वन्नावत्सराद् गणकः ॥ ९०[4] ॥
एक[3]दिनावमशेषं षट्[1] गणमेकरविचन्द्रभगणोनम्[2] ।
शुध्यति भूदिनभक्तं[4] व्येकं चांद्रै स्तदुक्तिरियम् ॥ ९१[5] ॥
इषुशरकृताष्टदिग्भिः[4] १०८४५५ संगुणितादवमशेषाद्[5] भक्तात्[1] ।
रूपाष्टरसवेदरसशून्य[2]शरगुणैः[6] ३५०६४८१ दिनगणः[3] शेषम् ॥ ९२[8] ॥

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९०. (घ) (वि०—इसकी क्रमसंख्या ९१ है)
१. गण for (गुण) (ग) द्युगणमवमासशेषा for (द्युगुणमवशेषा)
२. मध्यमौं (च) for (मध्यमौ)
(ग) ३. स्फुटावथवा for (स्फुटादथवा) (वि०—इसकी क्रमसंख्या ९० है)
(च) १. द्युगण for (द्युगुण)
४. (वि०—क्रमसंख्या ९१ अंकित है)
(ङ) १. गुणमवमावशेषा for (गुणमवशेषा)

९१. (घ) (वि०—इसकी क्रमसंख्या ९२ है)
(ग) १. चद्गुण for (षट्गुण) २. सगणोना for (भगणोनम्)
३. एकादिना for (एकदिना) ४. भूदिभक्तं for (भूदिनभक्तं)
(च) ५. (वि०—यहां क्रमसंख्या ९२ अंकित है)
(ङ) ३. एकदिनमवमशेषं for (एकदिनावमशेषं)
१. यद्गुणमेक for (षट्गणमेक)

९२. (घ) (वि०—इसकी क्रमसंख्या ९३ है)
१. दवमवशेषकाद् for (दवमशेषाद्भक्तात्)
२. रूपाष्ट वेदरसशून्य (ग) for (रूपाष्टरसवेदरसशून्य)
३. दिनगणः (ङ) (च) for (दिनगणः)
(ग) ४. इष्टशरकृताष्टदिग्भिः for (इषुशरकृताष्टदिग्भिः)
५. देवमशेषकाभक्तात् for (दवमशेषाद् भक्तात्)
६. रगुणो for (शरगुणैः)
(च) १. दवमवशेषकाद्भक्तात् for (दवमशेषाद्भक्तात्)
२. वेदरस (ङ) for (रसवेदरस)
८. (वि०—क्रमसंख्या ९३ अंकित है)
(ङ) १. शषेकाद्भक्तात् for (शेषाद्भक्तात्)

जिनरस गोब्धिरद्[1]गुणा ३२४[4]६६२४ छशि[5] वसुकृत रसखभुत[2]रामहूतान्[3] ।
इष्टावमशे[6]षाद्यछेषं रविभगण शेषं तत्[7] ॥ ९३ ॥
गोगें[3]दुखेश ११०[4]१७९ गुणित[1]द्भुक्तान्नख[5]पक्षयम रसेषु[8] गुणैः[7] ३५६२२२०[2] ।
शे[6]षमवमावशेषात्तिथयो वमशेषकाद्विकलम् ॥ ९४ ॥
भागकलाविकलैक्यं दृष्ट्वा विकलांतरं न[1] के शेषैः[6] ।
ऐक्यं द्विधां[3]तराधिकहीनं द्विवि[4]भाजितं शेषम्[2] ॥ ९५ ॥[5]

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९३. (घ) (वि०—इसकी क्रमसंख्या ९४ है)
१. रदगुणा (ग) रसगुणा for (रद्गुणा)
२. भूत (ग) (ङ) for (भुत)
३. हूतान् । ३५६४८१ (ग) राहूतात् for (रामहूतान्)
(ग) ४. (वि०—संख्या के अंक लुप्त हैं) ५. शशि (ङ) for (छशि)
५. शेषाद्या for (शेषाद्य)
(च) १. रदगुणा for (रद्गुणा) २. भूत for (भुत)
३. रामहूतान् for (रामहूतान्) ७. वि०—यहां क्रमसंख्या ९४ अंकित है)
(ङ) १. गोऽब्धिरद ३२४९६२४ गुणात् for (गोब्धिरद्गुणा ३२४९६२४)
३. हूतात् for (हूतान्) ६. शेषाद्य्शेषं for (शेषाद्यछेषं)

९४. (घ) (वि०—इसकी क्रमसंख्या ९५ है)
१. गुणिताद्भुक्ता (ग) (च) (ङ) for (गुणितद्भुक्ता)
२. '३५६२२२०' दूसरी पंक्ति का आरंभ (य) संख्या लुप्त
(ग) ३. गोगेदुशेख for (गोगेंदुखेश) ४. संख्या के अंक लुप्त हैं
५. नाख for (न्नख) ६. शेषावमाव for (शेषमवमाव)
(च) ७. गणैः for (गुणैः)
(वि०—यहां क्रमसंख्या ९५ अंकित है)
(ङ) ३. गोऽगेंदु for (गोगेन्दु)

९५. (घ) (वि०—इसकी क्रमसंख्या ९६ है)
१. वके शेषे (ग) च के शेषे for (नके शेषैः)
२. शेषे (ग) (ङ) for (शेषम्)
(ग) ३. द्विघातरा for (द्विधांतरा) ४. द्विभाजितं for (द्विविभाजितं)
(च) १. वकेशेषे for (नके शेषैः) २. शेषे for (शेषम्)
(वि०—क्रमसंख्या ९६ अंकित है)
(ङ) १. च for (न) ६. शेषे for (शेषैः)
३. द्विधाऽन्तरा for (द्विधांतरा) ४. च द्विभाजितं for (द्विभाजितं)

तद्वर्गांतरमाद्यं[५] तदंतरं चांतरोद्धृ[१]तयुतोनम् ।
वर्गांतरं विभक्तं[२] ताभ्यां[३] शेषोन्यतो[६] द्युगणः ॥ ९६[४] ॥
कृतिसंयोगाद्[४]द्विगुण[१] छेष[२]युतिकृति विशोध्य मूलेन ।
शेष युतिर्युत हीनाद्द्विहता[३] शेषे पृथक् युक्त्या[५] ॥ ९७[७] ॥
शेषवधाद्द्वि[१]ऋति गुणा छेषांतर[६]वर्गसंयुतान्मूले[२] ।
शेषांतरी[३]नयुक्तं दलितं शेषे पृथगभिष्टे[४] ॥ ९८[५] ॥

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९६. (घ) (वि०—इसकी क्रमसंख्या ९७ है)
१. चांतरोद्धृत (ग) (ङ) for (चांतरीद्धृत्र)
२. द्वा द्वाभ्यां for (ताभ्यां) ३. शेषे ततो (ग) (ङ) for (शेषोन्यतो)
(च) १ चांतरोद्धृत for (चांतरीद्धृत) ४. (वि०—क्रमसंख्या ९७ है)
३. शेषो ततो द्युगणः for (शेषोन्यतो द्युगणः)
(ङ) ५. माद्य for (माद्यं) २. द्वाभ्यां for (ताभ्यां)
९७. (घ) (वि०—इसकी क्रमसंख्या ९८ हैं)
१. द्विगुणा (ग) (च) for (द्विगुण)
२. छष for (छेष) (ग) छेष कृतियुतिं for (छेषयुतिकृति)
३. विहृता (ग) विज्ञता for (द्विहृता)
(ग) ४. कृत संयोगा for (कृतिसंयोगा) ५. पृथग्युक्त्या for (पृथक् युक्त्या)
(च) ६. द्विहृता for (द्विहृता)
६. (वि० — क्रमसंख्या ९८ अंकित)
(ङ) कृतिसंयोगाद् द्विगुणाद्युतिवर्गं प्रोह्य शेषमूलं यत् ।
तेन युतोनो योगो दलितः शेषे पृथगभींष्टे ॥ ९८ ॥
for
(कृतिसंयोगाद्विगुण छेषयुतिकृति विशोध्य मूलेन
शेषयुतिर्युतहीना द्विहता शेषे पृथक् युक्त्या ॥ ९७ ॥)
९८. (घ) (वि—इसकी क्रमसंख्या ९९ है)
१. विकृति (ग) for (द्विऋति) मूलम् (ग) (ङ) for (मूले)
३. शेषांतरोन (ग) (ङ) for (शेषांतरीन युक्तं)
४. पृथगगभीष्टे (ग) (ङ) for (पृथगभिष्टे)
(ङ) १. कृति for(ऋति) २. मूलं for (मूले)
४. पृथगभीष्टे for (पृथगभिष्टे)
५. (वि० — क्रमसंख्या ९९ अंकित है)
(ङ) १. वधाद् द्विकृतिगुणात् for (वधाद्विऋतिगुणा) ६. शेषांतर for (छेषान्तर)

सुखमात्रममी[2] प्रश्ना[6] प्रश्नान्यात्सहस्रशः[1] कुर्यात् ।
अन्यैर्दत्तात्[3]प्रश्नानुक्तं[7] वा साधयेत्करणैः[4] ॥ ६६[5] ॥

जन संसदि दैवविदां तेजो नाशयति भानुरिव[2] भानाम् ।
कुट्टाकार[3]प्रश्नैः[4] पठितैरपि किं पुनर्ज्ञातैः[1] ॥ १००[5] ॥

प्रतिसूत्रममी[4] प्रश्नाः पठिताः सोद्देशकेषु सूत्रेषु ।
आयाणां[1] अधिकशते[2] कुट्टकोष्टादशो[6]ऽध्यायः ॥१०१[5]॥

[3]इति श्री ब्रह्मगुप्ते अष्टादशोऽध्यायः ।

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६६ (घ) (वि०—इसकी क्रमसंख्या १०० है)
१. प्रश्नानन्या (ग) प्रश्नानन्यान् (ङ) for (प्रश्नान्यात्)
(ग) देव्यात्र for (सुखमात्र) ३. दत्तान् for (दत्तात्) ४. त्करणैः for (करणैः)
(च) १. प्रश्नानन्यान्सहस्रशः (प्रश्नान्यात्सहस्रशः)
(वि०—इसकी क्रमसंख्या १०० अंकित है)
(ङ) २. हृदि घात्रममी for (सुखमात्रममी) ६. प्रश्नाः for (प्रश्ना)
३. अन्यैर्दत्तान् for (अन्यैर्दत्तात्) ७. प्रश्नानुक्त्यैवं for (प्रश्नानुक्तं वा)
४. करणैः for (करणैः) (वि०—३. 'हृतान्मात्रममी' इति सुधाकरः)

१००. (घ) (वि० - इसकी क्रम संख्या १०१ है)
१. पुनर्ज्ञातैः (ग) (च) for (पुनर्ज्ञातैः) २. भारिव for (भानुरिव)
३. कुदाकारं for (कुट्टाकार) ४. प्रस्नैः for (प्रश्नैः)
(च) ३. कुदाकार प्रश्नैः for (कुट्टाकार प्रश्नैः)
५. (वि०—यहाँ क्रम संख्या १०१ अंकित है)
(ङ) १. पुनः शतशः for (पुनर्ज्ञातैः)

१०१. (घ) (वि०—इसकी क्रम संख्या १०२ है)
१. आर्याणाम् (ग) आर्या for (आयाणां) २. शतेन कुष्ट for (शते कुट्ट)
३. 'इति' से 'अध्यायः' तक अंकित नहीं है ।
(ग) २. समी प्रश्नाः for (ममी प्रश्नाः) २. शतेन for (शते)
३. इति श्रीब्रह्मसिद्धांते कुट्टकाध्यायाष्टदशमः ॥ १८ ॥ for (इति श्रीब्रह्मगुप्ते-अष्टादशोऽध्यायः)
(च) १. आर्याणां for (आयाणां)
३. "इति" से "अध्यायः" लुप्त (केवल "श्री" अंकित है)
५. (वि०—क्रमसंख्या १०२ अंकित है)
(ङ) १. आर्या for (आयाणां) २. अधिकशतेन for (अधिकशते)
६. कुट्टश्चाष्टादशो for (कुट्टकोष्टादशो)

अथ शंकुच्छायादिज्ञानाध्यायः

एकोनविंशः

द्दष्ट्वा दिनार्द्धघटिका योर्कजो[1] क्षांशकान्[3]वीजानाति[2]।
उदयांतरघटिकाभिर्ज्ञाता[4] ज्ञेयं स तन्त्रज्ञः ॥ १ ॥
अस्तांतर्घटिकाभिर्यो[1] ज्ञाताज्ञेयमानयति[6] तस्मात्।
मध्यगति[2] ग्रहभगणाननयति[3][4] तया[5] स तंत्रज्ञः ॥ २ ॥
आनयति यस्तमो रविशशांक मानानि दिप[1] कौच्यतलात्।
शंकुतलांतरभूमि[2] ज्ञाने छायां स तन्त्रज्ञः ॥ ३ ॥
छायाद्वितीयाग्रांतर[1] विज्ञाने[4] वेत्ति दीपौच्ये[2]।
शंकु[5] छायाज्ञो वा यछायौच्ये[3] स तंत्रज्ञः ॥ ४ ॥

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१. (घ) १. ऽर्कज्ञो (ग) (ङ) for (योर्कजो) २. विजानाति (ग) for (वीजानाति)
(च) १. योऽर्क्कजो for (योर्कजो) २. विजानाति for (वीजानाति)
(ङ) ३. ऽक्षांशकान् for (क्षांशकान्) २. विजानाति for (वीजानाति)
४. र्ज्ञाताज्ज्ञेयं for (र्ज्ञाता ज्ञेयं)

२. (घ) १. अस्तांतर (ग) for (अस्तांतर्) २. मध्यगतिं (च) (ङ) for (मध्यगति)
(ग) ३. युगभ (ङ) for (ग्रहभ) ४. नानयति (च) (ङ) for (ननयति)
५. ततः (ङ) for(तया) (वि०—इसकी क्रम संख्या १ लिखी है)
(च) १. अस्तांतर घटिकाभिर्यो (ङ) for (अस्तांतर्घटिकाभिर्यो)
(ङ) ६. ज्ञाताज्ज्ञेय for (ज्ञाताज्ञेय)

३. (घ) १. दीपाक्ये वचच्यतलात् (ग) दीपक शिखोन्याः for (दिपकौच्यतलात्)
(ग) २. भूमि (ङ) for (भूमि) (वि०— इसकी क्रमसंख्या २ लिखी है)
(ङ) १. दीपकशिखोच्च्यात् for (दिपकौच्यतलात्)

४. (घ) १. छायाद्वितया (ग) for (छायाद्वितीया)
२. भूमिदीपौच्ये (ग) दीप्यौच्ये for (दीपौच्ये)
(ग) ३. परभूमेत्छायां for (यछायौच्ये) (वि०—इसकी श्लोक संख्या ५ है)
(च) १. द्वितया for (द्वितीया)
(ङ) १. छायाद्वितीयभाग्रान्तर for (छायाद्वितीयाग्रांतर)
४. विज्ञानेन for (विज्ञाने) २. दीपौच्यम् for (दीपौच्ये)
५. शङ्कुच्छायाज्ञो for (शंकुछायाज्ञो) ३. भूमेश्छायां for (यछायौच्ये)

दृष्टि[4]गृहौच्यज्ञो य: [6]स्तदंतरज्ञो [1]नराकृते [2]नुजले ।
[3]गृहभित्यग्रे दर्शयति [5]दर्प्पणे वा स तंत्रज्ञः ॥ ५ ॥
[1]हग्रहतलांतर[4]जले यो [5]दृष्ट्वाग्रं [2]गृहस्य भूमिज्ञः ।
वेत्ति [3]गृहौच्यं दृष्ट्वा तैलस्थं [6]वा स तंत्रज्ञः ॥ ६ ॥
[6]वीक्ष [1]गृहाग्रं सलिले प्रसार्य सलिलं [4]पुनश्चभूज्ञाने ।
आनयति जला[2]द्भूमि [3]गृहस्य [5]चौच्यं स तंत्रज्ञः ॥ ७ ॥
[4]ज्ञातै छाया [5]पूरुषै [6]विज्ञाते तोय [1]कुघयो विवरे ।
[2]कुट्टके तेजसो यो [3]वेत्थारुढ़ैः स तंत्रज्ञः ॥८॥

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५. (घ) १. नरात्कृते (ग) for (नराकृते) २. तु (ग) (ङ) for (नु)
३. गृहभित्यर्गं (ग) गृहभित्यग्र (ङ) for (ग्रहभित्यग्रे)
(ग) ४. इष्टग्रहौच्यज्ञो for (दृष्टिगृहौच्यज्ञो) ५. दर्पणे (ङ) for (दर्प्पणे)
(वि०—इसकी श्लोक संख्या ४ है)
(च) १. नराकृते for (नराकृते)
(ङ) ४. इष्टगृहौच्यज्ञो for (दृष्टिगृहौच्यज्ञो) ६. यस्तदन्तरज्ञो for (यः स्तदंतरज्ञो)
१. निरीक्ष्यते for (नराकृते)
६. (घ) १. नृग्रह दृग्ग्रहनलांतर (ङ) for (ह्रग्रह तलांतर)
२. गृहस्य (ग) (च) (ङ) for (ग्रहस्य)
३. गृहोच्यं (ग) गृह्यौच्यं (च) (ङ) for (ग्रहौच्यं)
(ग) ४. जलयो for (जले यो) ५. दृंष्ट्वाग्रं (ङ) for (दृष्ट्वाग्रं)
६. व for (वा)
(च) १. दृग्रहतलांतर for (हृग्रहतलांतर)
(ङ) १. दृष्ट्वा गृहतलान्तर for (हृग्रहतलांतर) ४. जालभो for (जले यो)
७. (घ) १. गृहाग्रं (ग) (च) (ङ) for (ग्रहाग्रं) २. भूमिं (ग) (च) (ङ) for (भूमि)
३. गृहस्य (ग) (च) (ङ) for (ग्रहस्य)
(ग) ४. पुनः स्वभूज्ञाने (ङ) for (पुनश्च भू ज्ञाने) ५. वौच्यं for (चौच्यं)
(ङ) ६. वीक्ष्य for (वीक्ष)
८. (घ) १. कुडचयोर्विवरे (ङ) for (कुघयोर्विवरे)
२. कुडचर्के (ग) कुधेर्का for (कुट्टके)
३. वेत्त्यारूढ़ि (ग) वेत्त्यारूढ़ैः for (वेत्थारूढ़ैः) (ग) ४. ज्ञाते for (ज्ञातै)
५. पुरुषै (ङ) for (पूरुषै) ६. विज्ञातै for (विज्ञाते)
(च) १. कुडचयो for (कुघयो) २. कुट्टेऽर्के for (कुट्टके)
(ङ) १. ज्ञातैश्छाया for (ज्ञातै छाया)
२. कुडचेर्के for (कुट्टके) ३. वेत्यारूढ़ि for (वेत्थारूढ़ैः)

इष्ट दिवसार्द्ध घटिका घटिका च[1] दशकांतरं[2] प्राणाः ।
तद्दिवसचरप्राणास्तैरक्षं साधयेत्प्राग्वत्[3] ।। ९ ।।
ज्ञातः सभार्द्ध उदयैरस्तांतरनाडिकाभिरधिको नः ।
ज्ञातात्पूर्वापरयोर्ज्ञेयो[1] भार्द्धोनके[2] ज्ञयः[3] ।। १० ।।
ज्ञात[2]ज्ञेय[3]ग्रहयोरूदयांतरनाडिकाभिरधिकोनः[4] ।
उदयैर्ज्ञातो[5] ज्ञाताज्ञेये[6] प्राग[1]धरयोर्ज्ञेयः[7] ।। ११ ।।[8]
ज्ञातं कृत्वा मध्यं भूयोन्यदिने तदंतरं भुक्तिः ।
त्रैराशिकेन मुक्त्या[1] कल्पग्रहमंडलानयनम् ।। १२ ।।
स्थित्यर्द्धाद्विपरीतं तमः प्रमाणं स्फुटं[1] ग्रहणे ।
मानोदयाद्रवींद्वोर्घटिकावयवेन भोदयतः ।। १३ ।।

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९. (घ) १. पंचदशकांतर for (चदशकांतरं)
(ग) २. दशांतर for (दशकांतरं)
३. प्रास्नात् for (प्राग्वत्)
(ङ) शी० + अथोत्तराणि +
१. २. पंचदशांतर for (चदशकांतरं)

१०. (च) (वि०—यह श्लोक यहां ११ वीं क्रमसंख्या पर अंकित है)
१. ज्ञेये for (ज्ञेयो) २. भार्द्धोनको for (भार्द्धोनके)
३. ज्ञेयः (ङ) for (ज्ञयः)
(ङ) (वि०—यहां इसकी क्रमसंख्या ११ है)

११. (घ) १. परयो for (धरयो) (ग) प्रागपरो for (प्रागधरयो)
(ग) २. स्थान रिक्त है, ३. 'ज्ञेय' अक्षर लुप्त है ४. नम् for (नः)
५. ज्ञातो for (ज्ञांतो) ६. ज्ञाताज्ञेय for (ज्ञाताज्ञेये)
७. ज्ञेयः for (ज्ञेंयः)
(वि०—इसकी क्रमसंख्या १० है)
(च) १. प्रागपरयो for (प्रागधरयो)
८. (वि०—इसकी क्रमसंख्या १० अंकित है)
(ङ) ६. ज्ञाताज्ज्ञेयः for (ज्ञाताज्ञेये)

१२. (घ) १. भुक्त्या (ग) (च) (ङ) for (मुक्त्या)

१३. (घ) १. शशिग्रहणे for (स्फुटं ग्रहणे)

दीपतलशंकुतलयोरंतरमिष्टप्रमाणशंकुगुणम् ।
दीपशिखौच्याच्छंकुं विशोध्य शेषोद्धृतं छाया ॥ १४ ॥
शंक्वंतरेण गुणिता छाया छायांतरेण भक्ता भूः ।
स छाया शंकुगुणा दीपोच्च्यं छायया भक्ता ॥ १५ ॥
ज्ञात्वा शंकुछाया मनुपातात्साधयेत्समुछ्रायान् ।
गृहचैत्यतरू नगानामौच्च्यं विज्ञायवछायाम् ॥ १६ ॥
दृष्टि गृहौच्च्यैक्य हृतातदन्तरधरादगौच्य गुणिता ।
फलभून्यस्ते तोये प्रतिरूपाग्रं गृहस्य नरात् ॥ १७ ॥

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१४. (घ) १. छंकु for (च्छंकु)
(ग) १. शिखौच्यात् शंकुं for (शिखौच्याच्छंकु)
२. हृतं (च) for (द्धृतं) ३. छायाः for (छाया)
(च) ४. दीपशिषौच्या for (दीपशिखौच्या)
(ङ) ४. शिखौच्च्याच्छङ्कुं for (शिखौच्याच्छंकु)

१५. (घ) १. दीपौच्यं (ग) (ङ) for (दीपौच्च्यं)
(ग) २. भक्ताः (च) for (भक्ता)
(ङ) ३. सच्छाया for (सछाया)

१६. (घ) १. वा (ग) (च) (ङ) for (व)
(ग) २. मनुपातान् for (मनुपातात्)
(ङ) ३. शङ्कुच्छाया for (शंकुछाया)
४. समुच्छ्रायान् for (समुछ्रायान्)
५. मौच्च्यं for (मौच्यं)

१७. (घ) १. गृहौच्चैक्य (ग) ग्रहौच्येक for (गृहौच्यैक्य)
(ग) २. हृता (च) (ङ) for (हृता)
३. दृगौच्यमं for (धरादगौच्य)
(च) १. गृहौच्चैक्य for (गृहौच्यैक्य)
३. दृगौच्य for (दगौच्य) (ङ) ४. युतदृष्टि for (दृष्टि)
१. गृहौच्च्य for (गृहौच्यैक्य) ५. ह्यन्तर for (तदन्तर)
३. भूमिदृगौच्च्य for (धरादगौच्य) ६. संगुणिता for (गुणिता)
७. न्यैस्ते for (न्यस्ते)

गृह पुरूषांतर सलिले[४] विक्ष्य[१] गृहाग्र[२] दृगौच्य[५] संगुणितम् ।
गृहतोयांतरमौच्यं[७] गृहस्य नृजलांतरेण[६] हृतम्[३] ॥ १८ ॥
प्रथम[५] द्वितीय[६] नृजलांतरांतरेणोद्धृता[२] जलाय[१] सृतिः ।
दृष्टौच्य[७] गुणोच्छ्राय[३]स्तोयानृजलांतर[४]गुणा भूः ॥ १९ ॥
छाया पुरूषछिन्नं[८] जल[१] कुधांतर[२] मवाप्तमारूढ़िः[५] ।
अध्याये[३] विंशत्यार्याणा[६]मेकोनविंशोयम्[७] ॥ २० ॥

इति[४] ब्रह्म गुप्ते छायाध्यायः

एकोनविंशोऽध्यायः समाप्तः

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१८. (घ) १. वीक्ष्य (ग) (च) (ङ) for (विक्ष्य)
२. गृहाग्र (ग) (च) (ङ) for (ग्रहाग्र)
३. हृतम् (ग) (च) (ङ) for (हूतम्)
(ग) ४. सलिल for (सलिले)
५. व्यसंगुणितम् for (दृगौच्यसंगुणितम्)
६. नृतलांतरेण for (नृजलोन्तरेष)
(च) ५. दृगौच्च्य for (दृगौच्य)
७. मौच्च्यं for (मौच्यं)

१९. (घ) १. जलापसृतिः (ग) (ङ) for (जलाय सृतिः)
(ग) २. नृजलांतरांतरा for (नृजलांतर) ३. छाया for (छाय)
४. स्तोयन्नृजलांतर for (स्तोयानृजलांतर)
(च) ५. प्रथ for (प्रथम) ६. द्वितिय for (द्वितीय)
(ङ) ७. दृष्टचौच्च्य for (दृष्टौच्य) ३. गुणोच्छ्राय for (गुणोछ्राय)

२०. (घ) १. बल for (जल) ३. कुटचांतर (च) for (कुधांतर)
३. अध्यायो (ग) अध्याय for (अध्याये)
४. 'इति' से 'समाप्त' तक पाठ उपलब्ध नहीं (ग)
(ग) ५. मवामारूदिः for (मवाप्तमारूदिः) ६. विशत्यार्याणा for (विंशत्यार्याणां)
७. मेकान विंशोयम् for (मेकोनविंशोयम्)
(च) ३. अध्यायो (ङ) for (अध्याये) ४. 'इति' से 'समाप्त' तक पाठ लुप्त ।
(ङ) ८. च्छिन्नं for (छिन्नं) २. कुड्यान्तर for (कुधांतर)
४. इति श्री ब्राह्मस्फुटसिद्धान्ते शंकुच्छायादिज्ञानं नामैकोनविंशोऽध्यायः for (इति ब्रह्मगुप्ते छायाध्यायः)

अथ छन्दश्चित्युत्तराध्यायो

विशंतितमः

ऋग्वर्गः[१] पर्यायः[२] समूह योगो[३] वयुक्षु[४] युग्मेषु ।
सोपाः[८] प्राग्वत्[६]पादाश्चतुष्कका[५] शेष युक्तोंत्यः[७] ॥ १ ॥
एकैक[३] युत विहीना वाद्यंतौ[१] तद्विपर्ययो[४] यावत् ।
वर्गादिष्व[५] समयुजः[६] क्रमोक्रमाद्[२]द्धयेत्पादान् ॥ २ ॥
एकैकेनद्वाद्या[३] न[४] सोयेष्ट्[१]धिकेषु तत्प्रविष्टेषु[५] ।
वर्गादिरीष्टांत[२] प्रस्तारो भवति यवमध्यात्[६] ॥ ३ ॥

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१. (घ) १. रिग्वर्गः (ग) ऋग्वर्क्कः for (ऋग्वर्गः)
२. पर्यायः (ग) (च) (ङ) for (पर्यार्यः) ३. योगा (ङ) for (योगो)
४. वयुत्कु (ग) वपुक्ष for (वयुक्षु)
५. चतुष्ककाः (ग) (च) (ङ) for (श्चतुष्कका)
(ग) ६. प्रागृत for (प्राग्वत्)   ७. युक्तोत्यः for (युक्तोंत्यः)
(ङ) ८. सोयाः for (सोपाः)   ९. प्राप्तादा for (पादा)

२. (घ) १. विहीनाद्यंतौ (ग) वाद्यंतै for (वाद्यंतौ)
२. क्रमोत्क्रमाद् (ग) क्रमात् (ङ) for (क्रमोक्रमाद्)
(ग) ३. एकादि (ङ) for (एकैक)   ४. तद्विपर्यायौ for (तद्विपर्ययो)
५. वर्गादिषु (ङ) for (वर्गादिष्व) ६. विषमयुजाक्रमो for (समभुजः)
(च) २. क्रमोत्क्रमाद्वर्द्धयेत् for (क्रमोक्रमाद्वर्द्धयेत्)
(ङ) ४. तद्विपर्ययौ for (तद्विपर्ययो) ६. विषमयुजां for (समभुजः)

३. (घ) १. सोपेश्वधिकेषु for (न सोयेष्टधिकेषु)
२. भीष्टां (ग) वर्गादिरभीष्टांतः for (वर्गादिरीष्टांत)
(ग) ३. द्व्याव्याः for (द्वाद्या) ४. सोपेप्पधिकेषु for (न सोयेष्टधिकेषु)
५. तत्प्रतिष्ठेषु (ङ) for (तत्प्रविष्टेषु)
६. मध्यः (ङ) for (मध्यात्)
(च) १. नसोपेष्वधिकेषु for (नसोयेष्टधिकेषु)
(ङ) ३. द्व्याद्व्याः for (द्वाद्या)   १. सोप्पप्पधिकेषु for (न सोपेष्टधिकेषु)
२. वर्गाद्रिरभीष्टान्तः for (वर्गादिरीष्टांत)

[1]न्यूनोचोद्विपदाग्रं विप[4]दाद्या नामतः पृथक् संख्या ।
तछो[2]धोथेव्येकः पृथगं[5]तापमूर्द्धं [3]युतम् ॥ ४ ॥
यावत्पादा[2]व्ये[4]का गछद्व[3]र्गो[1]ष्वथैकं वृद्धेषु ।
रूपा[5]द्युद्धृतघाते वर्गाद्यानां परा संख्या ॥ ५ ॥
रूपाधि[1]कयोर्द्धं विषमे [2]पूर्वः समेषु पादार्द्धे ।
[3]आद्या [4]द्विगुणाव्येकां गुलान्यधस्तस्य सर्वेषाम् ॥ ६ ॥
[1]मध्येस्तथार्द्धहीनैः क्रमपादैर्व्य[5]स्त तुल्य पादाद्यैः[6] ।
विषमे[7]ष्वेकं मध्ये [2]प्रो[3]ह्याद्यान्यतः [4]कुर्यात् ॥ ७ ॥

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४. (घ) १. न्यूनोन्यो (ग) न्यूनोद्विपादाग्रं for (न्यूनो चो)
२. ताश्चांधोध्योव्येक for (तछोधोथेव्येकः) ३. 'धे' लुप्त
(ग) ४. त्रिपदाद्यानाममधः for (विपदाद्यानामतः) २. व्यव्येकः for (व्येकः)
५. पृथगंताद्रूपमूर्द्धयुतम् for (पृथगंतापमूर्द्धंयुतम्)
(च) १. न्यूनोंचो for (न्यूनोचो) २. ताँछोधोथे for (तछोधोथे)
५. पृथगंताद्रूमपूर्द्धयुतं for (पृथगंतापमूर्द्धयुतम्)
(ङ) १. सूनोन्त्यो for (न्यूनो चो)
४. त्रिपदाद्यानामधः for (विपदाद्यानामतः) २. तच्छोध्यो for (तछोधोथे)
५. पृथगन्ताद्रूपमूर्ध्वंयुतम् for (पृथगंतापमूर्द्धंयुतम्)
५. (घ) १. चैक for (थैक)
(ग) २. व्येको for (व्येका)
३. गच्छद्वर्गोप्यथैकवृद्धेषु for (गच्छद्वर्गोष्वथैकवृद्धेषु)
(ङ) ४. गच्छाद् for (गच्छेद्) ५. रूपाद्युतघाते for (रूपाद्युद्धृतघाते)
६. (घ) १. रूपाधिकपादार्धे (ङ) (ग) रूपाधिकापादार्धे for (रूपाधिकयोर्द्धं)
३. अज्या for (आधा)
(ग) २. विषमेषूर्द्धस्समेषु पादा for (विषमेपूर्वः)
३. अर्द्धाद्विगुणाव्येकां (ङ) for (आधाद्विगुणाव्येकां)
(च) १. रूपाधिकपादार्द्धं for (रूपाधिकयार्द्धं) ३. अद्या for (आद्या)
(ङ) २. विषमेषूर्ध्वः for (विषमेपूर्वः) ४. युलान्यधस्तस्य for (गुलान्यधस्तस्य)
७. (घ) १. (मध्यैं) (ग) मध्यै for (मध्ये) २. मधे for (मध्ये)
२. प्रोच्याद्यान्यन्यतः for (प्रोह्याद्यान्यतः) ४. र्यान् for (कुर्यात्)
(ग) ५. व्यस्तुल्य for (र्व्यस्ततुल्य)
(ङ) १. माध्यै for (मध्ये) ६. पादाद्यः for (पादाद्यैः)
७. विषमेरव्येकं for (विषमेष्वेकं)

सैवक्रम[3] तुलाद्यै[1]र्न्यासोऽप्यधिको[2] विशोधितश्चाधः ।
सांख्यैक्यं[4] तादृक्[5] तादृक्[7] प्रथम[6]स्त्रिरहितो नष्टे ॥ ८ ॥
माध्यैः[1] कृतैश्चदलितै[4] सम संख्यायां क्रमोक्रमा[2]क्षेप्यम्[5] ।
विषमायां व्येकायां दलं क्रमादुक्रमात्[3] सैकम् ॥ ९ ॥
समसंख्यायां[1] सोपात्[7] क्रमोक्रमाभ्यां[2] तथैव विषमायाम्[8] ।
कल्पोपविते[3] दृष्टे[5] प्रथमः शेषा[6]क्षराण्यंते[4] ॥ १० ॥
समदलसम विषमाणां संख्यापादार्द्धं[1] सर्वकल्पवधः ।
स्वाद्य[2] वधोन्यैः पादैः स्वपरस्य प्राग्वधः सैकैः ॥ ११ ॥

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८. (घ) १. तुल्याद्यै (ग) (ङ) for (तुलाद्यै)
२. व्यधिको (ग) न्सिोभ्यधिको (ङ) for (न्यासोप्यधिको)
(ग) ३. सैकक्रमं for (सैवक्रम) ४. संख्यैक्य (ङ) for (सांख्यैक्य)
५. तादिक् यादिक्च for (तादृक् तादृक्) ६. यस्त्रि for (प्रथमस्त्रि)
(च) ३. सैकक्रम (ङ) for (सैवक्रम) ४. सोख्यैक्य for (सांख्यैक्य)
(ङ) ७. यादृक् for (तादृक्)

९. (घ) १. माध्येः (ग) मध्यैः for (माध्यैः)
२. क्रमोत्क्रमा (ग) (च) for (क्रमोक्रमा)
३. दुत्क्रमात् (च) for (दुत्क्रमात्)
(ग) ४. दलितैः (च) (ङ) for (दलितै) ५. त्क्षेप्यम् for (क्षेप्यम्)
(ङ) २. क्रमोत्क्रमात् for (क्रमोक्रमा) ५. क्षेप्पम् for (क्षेप्यम्)

१०. (घ) १. संक्षाया for (संख्यायां)
२. क्रमोत्क्रमाभ्यां (ङ) (ग) क्रमत्क्रमाभ्यां for (क्रमोक्रमाभ्यां)
३. कल्पोपवितो (ग) कल्पोपचिते for (कल्पोपविते)
४. शेषात्कराण्यंते for (शेषाक्षराण्यन्ते)
(ग) ५. दृिष्टे for (दृष्टे) ६. शेषाः for (शेषा)
(च) २. क्रमोत्क्रमाभ्यां for (क्रमोक्रमाभ्याम्)
(ङ) ७. सोपान for (सोपात्) ८. विषमाभ्याम् for (विषमायाम्)
३. कल्प्यापचिते for (कल्पोपविते)

११. (घ) १. संक्षापार्द्ध (ग) सख्यापा for (संख्या)
(ग) २. स्वाद्य for (स्वाद्य)
(ङ) १. संख्यापादार्ध for (संख्यापादार्द्ध)
२. स्वाद्यवधोऽन्यैः for (स्वाद्यवधोन्यैः)

आद्याद[६]नंतरोधः कल्पोत्य[१] तुल्य माद्य कल्प[५] प्राक् ।
न्यासो[२] वर्गोन्योन्य[३] प्रस्तारे[४]र्द्ध समविषमाणाम् ॥ १२ ॥
नष्टां[१]त्पास्वाधस्थो न कल्प[४] घातो[२] अर्द्धं[५] तुल्य विषमाणाम् ।
व्येकः पृथक् स्ववर्गो[३]द्धृतः[६] फलं तुल्य कल्पानाम् ॥ १३ ॥
उद्दिष्टे[४] कल्प कृतो[१] तीतै[६] प्रथम फल[२]स्वरूपेन्यः ।
असकृ[३]द्वर्गांश युते सैके [५]वार्द्ध सम विषमाणाम् ॥ १४ ॥

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१२. (घ) १. कल्पोऽनु (ग) कल्पोन्य for (कल्पोत्य)
२. न्यास्पोवर्ग्रो (ग) न्यासो च गोन्यो न for (न्यासोवर्गो)
३. न्योत for (न्योन्य)
४. प्रस्तारेऽर्ध (ग) (च) for (प्रस्तारेर्द्ध)

(ग) ५. कल्पः for (कल्प)

(च) १. काल्पोऽन्यतुल्य for (कल्पोत्यतुल्य) ३. न्योन for (न्योन्य)

(ङ) ६. दनन्तरोऽधः for (दनंतरोधः)
१. कल्प्पोऽन्यतुल्यमाद्यः for (कल्पोत्यतुल्यमाद्य)
५. 'कल्प' लुप्त ।
४. प्रस्तारोऽर्ध for (प्रस्तारेर्द्ध)
३. ऽन्योनः for (न्योन्य)

१३. (घ) १. नष्टांत्याश्चोस्थोन for (नष्टांत्पास्वाधस्थोन)
२. र्द्धं (ग) (च) (ङ) ऽर्ध for (अर्द्धं) ३. वर्ग्रो for (वर्गो)

(ग) १. नाष्टंत्यात् for (नष्टांत्) ५. ककल्प for (नकल्पा)
६. तुविषमाणाम् for (तुल्यविषमाणाम्) ७. द्धृतफलः for (द्धृतः फलं)

(ङ) १. नष्टेऽन्त्यात् for (नष्टांत्पा)

१४. (घ) १. कृतेऽतीतैः (ग) हृतेतीतैः (ङ) for (कृतोतीतैं)
२. फले (ङ) for (फल)
३. वर्ग्रांश (ग) व्यसकृद्वर्गांश for (असकृद्वर्गांश)

(ग) ४. उद्दिष्ट for (उद्दिष्टे) ५. चार्ध for (वार्द्ध)

(च) १. कृतेऽतीतैः for (कृतोतीतैं)

(ङ) ६. प्रथमः for (प्रथम) ५. वार्ध for (वार्द्ध)

कल्पेषु[1] पृथुगुरू[4] लघुतुल्यवधैक्यं[5] गुरु लघुनि[2] यवमध्ये ।
दलसम[6] विषम लघूनि स्वद्य[3] लघूनानि विषमेषु ॥ १५ ॥
ध्व्यापाः[1] कोष्टक वृद्ध्या[2] लघु[3] संख्यैकादि भाजिताः प्राग्वत् ।
विषमे ज्याघल[4] घूनो लघूनो[5] लघुभिर्मेरुः समादीनाम् ॥१६॥
एकद्विकयोः[2] परतो द्वि संगुणो नंतरो[4] द्विरूपोधः ।
वर्गा[1]परा[3]द्योनोदल समविषमाणां ध्वजो लघुभिः ॥ १७ ॥
लघु संख्यादौ[2] परतो दलिता घोधश्च[6] शुध्यति हृताद्यैः[3] ।
द्विगुणांतैः[4] संख्यै[8] शुद्धैर्वर्ग[5] परै[1]र्मंदरो लघुभिः[7] ॥ १८ ॥

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१५. (घ) १. कल्पपृथुगुरू for (कल्पेषु) २. लघूनि for (लघुनि)
३. स्वाद्य (च) for (स्वद्य)
(ग) १. कल्प्पेषु for (कल्पेषु) ४. पृथग्गुरुलघु (ङ) for (पृथुगुरुलघु)
५. संख्यैकादिभाजिताः प्राग्वत् (ङ) for (तुल्यवधैक्यं गुरुलघुनि यवमध्ये)
६. विषमेष्वाद्यलघूनो लघुभिर्मेरुः समादीनाम् ॥ १५ ॥ (ङ)
for
(दलसम विषमलघूनि स्वद्य लघूनानि विषमेषु)
(च) २. लघूनि for (लघुनि)

१६. (घ) १. द्व्याद्याः (च) for (ध्व्यापाः) २. वृद्धा (च) for (वृद्ध्या)
३. लघू (च) for (लघु) ४. ज्याद्य for (ज्याघ)
(च) ४. द्याद्यल for (ज्याद्यल) ५. 'लघूनो' लुप्त ।
(ङ) यह श्लोक यहां उपलब्ध नहीं ।

१७. (घ) १. वर्ग्ग (ग) for (वर्गा)
(ग) २. द्वितयोः (ङ) for (द्विकयोः) ३. चराद्यो for (पराद्यो)
(च) १. वर्गं (ङ) for (वर्गा) ४. पराद्यां for (पराद्यो)
(ङ) (वि०—इसकी क्रमसंख्या १६ है) ४. ऽनन्तरा for (नंतरो)

१८. (घ) १. यरै for (परै)
(ग) २. संख्यापद दलिता परतो (ङ) for (संख्यादौ परतो दलिता)
३. हृताद्यैः for (हताद्यैः) ४. द्विगुणानांतैः for (द्विगुणान्तैः)
५. शुद्धैः वर्ग्ग for (शुद्धैर्वर्ग)
(च) ६. ध्येधश्च for (घोधश्च) ७. लघुंभि for (लघुभिः)
(वि०—इसकी क्रमसंख्या १७ है) ३. हृतायैः for (हताद्यैः)
६. ऽघोऽधश्च for (घोक्श्च) ८. 'संख्यै' लुप्त ।

कृत्वा[5]धोधः कल्पान्ये[1]काद्येकोत्तरान[2]धः शेषात् ।
खात्पर[3]तां तैकमधः प्रस्तारा द्युक्त[4]वदीहाद्यैः ।। १९ ।।
गुरूषष्ट्[7]यैंका विघटि[1] द्विगुणा [8]व्येकांगुलानि संख्याद्वा[2] ।
[6]विंशति रार्या विंश [3]छंदश्चि[4]तुत्तराध्यायः ।। २० ।।
[5]इत्ति ब्रह्म गुप्ते छंद श्चित्युत्तराध्यायः ।।२०।। अध्यायः समाप्तः
विशंतितमः समाप्तः ।

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१९. (घ) १. कल्पानेका for (कल्पान्येका)
२. धनः (ग) नघस्तेषाम् (ङ) for (नधः शेषात्)
३. खात्पतोंत्यैंक (ग) खात्परतोत्यैंक्चमधः for (स्वात्परतो ऽन्यैंक्चमधः)
४. वदिहाक्षैः (ग) वदेहाद्यैः for (वदीहाद्यैः)

(च) ५. ध्येधः for (धोधः)
१. कल्पानेकाद्येकोत्तरानधः for (कल्पान्येकाद्येकोत्तरानधः)
३. परतांत्यैंकमधः for (परतांतैकमधः)
४. वदिहाद्यैः for (वदीहाद्यैः)

(ङ) (वि०—इसकी क्रमसंख्मा १८ है)
१. कल्प्यान्येका for (कल्पान्येका) ४. दुक्तवदिहाद्यैः for (द्युक्तवदीहाद्यैः)

२०. (घ) १. विघटी द्विगुणाद्वच (ग) विघटी for (विघटि) २. स्या (ग) for (द्वा)
३. विशश्छंद (ग) विशच्छंद for (विंशछैंद)
४. श्चित्युत्तरोऽध्यायः (ग) (ङ) (श्चित्युत्तरोऽध्यायः)
५. 'इति' से 'समाप्त' तक पाठ उपलब्ध नहीं है । (ग)

(ग) ६. विशति for (विंशति)

(च) १. विघटी for (विघटि) २. संख्याध्या for (संख्याद्वा)
३. श्चित्युत्तराध्यायः for (श्चित्तुत्तराध्यायः)
५. 'इति' से 'समाप्त होने तक लुप्त ।

(ङ) (वि०—इसकी क्रससंख्या १९ है)
७. गुरुषष्टचेका for (गुरुषष्ट्यैंका)
१. निघटीद्विगुणा for (विघटिद्विगुणा)
८. न्येकांगुलानि for (व्येकांगुलानि) २. संख्या स्यात् for (संख्याद्वा)
६. द्राविंशतिरार्याणां for (विंशतिरार्याविंशं)

अथ गोलाध्यायो नाम

एकविंशतितमः

ग्रह नक्षत्रभ्रमणं न समं सर्वत्र भवति[3] भूस्थानम्[1] ।
तद्विज्ञानं गोलाद्यतस्ततो गोलमभिधास्ये[2] ।। १ ।।
शशि वुध सितार्क[4] कुज गुरु शनि कक्ष[1]विष्टितो[2]भ[3] कक्षांतः ।
भूगोलः सत्वानां शुभाशुभैः कर्मभिरूपात्तः ।। २ ।।
खेभूगोलस्तदुपरि मेरौ देवाः स्थितास्तले[3] दैत्याः
खे[1] भगणाक्षाग्रस्तावु[2] पर्यूधश्चा ध्रुवो[4] तेषाम् ।। ३ ।।
ध्रुवयो विद्धंस[1] व्यगम मराणां क्षितिज[2]संस्थमुडुचक्रम् ।
अपसव्यगमसुराणां भ्रमति प्रवहानि लाक्षिप्तम् ।। ४ ।।

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१. (घ) १. भूस्थानाम् (ङ) for (भूस्थानम्)
२. धास्येः for (धास्ये)
(ग) ३. 'भवति' पद यहां अंकित नहीं है ।

२. (घ) १. कक्ष्या (ग) कक्षा for (कक्ष)
२. चेष्टितो (ग) वेष्टितो for (विष्टितो)
(ग) ३. भक्षांत for (भकक्षांतः)
(च) ४. सितार्क्क for (सितार्क)
१. कक्ष्यावेष्टितो for (कक्षविष्टितो)
(ङ) १. कक्षावेष्टितो for (कक्षविष्टितो)

३. (घ) १. षे for (खे)
२. स्थावुपर्यधश्च (ङ) (ग) तावुपर्यधश्च for (स्तावुपर्यूधश्चा)
(ग) ३. स्थिताः स्तल for (स्थितास्तले) ४. ध्रुवौ for (ध्रुवो)
(च) २. क्षाग्रस्थावुपर्युधश्चा for (क्षाग्रस्तावुपर्यूधश्चा)

४. (घ) १. वंद्वंस (ग) बंद्धः for (विद्धंस)
(ग) २. क्षिति for (क्षितिज)
(च) १. वंद्वंस for (विद्धंस)
(ङ) १. बंद्ध for (विद्धं)

अन्यत्र सर्वतो दिशि[1]मुन्नम[2]तिभयं जरोध्रुवो भ्र[3]मति लंकायाः[4] ।
मुहु[5] चक्रं पूर्वापरगं ध्रुवौ क्षितिजे ॥ ५ ॥
देवा[1] सव्यगम सुराः[5] पश्यंत्यपसव्यगं[2] रविं क्षितिजे ।
विषुवति समपश्चिमगं नि[3]रक्षदेशास्थि[4]ताः पुरुषाः[6] ॥ ६ ॥
सौम्यमपमण्डलार्द्धं[2] मेषाद्यं[3] सव्यंग[4] सदादेवाः ।
पश्यंति तुलाद्यर्द्धं दक्षिणमप सव्यगं दैत्याः[1] ॥ ७ ॥
पश्यंति देवदैत्या रविवर्षार्द्धं[3]मुदितं सकृत्सूर्यम् ।
शशिगाः स[1]शिमासार्द्धं पितरोभूस्था नराः स्वदिवम्[2] ॥ ८ ॥
भूपरिधि तू[1]र्यभागे लंका[4]भूमस्त[6]का[5]क्षितितलाच्च ।
लंकोत्तरतो[2]वंती भूपरिधेः पंच दशभागैः[3] ॥ ९ ॥

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५. (घ) १. दिश (ग) दिशिषुन्नमति for (दिशिमुन्नमति)
२. तपंजरो for (भयंजरो) २. नमति (ग) (ङ) for (भ्रमति)
४. 'लंकाया' दूसरी पंक्ति का पहलापद (ग) (ङ)
५. मुडुचक्रं (च) (ङ) for (मुहुचक्रं)
(च) ३. नमति for (भ्रमति)
४. लंकाया (ङ) for (लंकायाः) ५. मुडुचक्रं for (मुहुचक्रं)
(ङ) १. दिशमुन्नमति for (दिशिमुन्नमति) २. भपंजरो for (भयंजरो)
६. (घ) १. देवाः (ग) (च)(ङ) for (देवा) २. सव्य गरविं for (सव्यगं रविं)
३. तिरक्ष for (निरक्ष) ४. देशस्थिताः (ग) (च) (ङ) for (देशास्थिताः)
(ग) ५. सुरा for (सुराः) (च) ६. पुरुषाः for (पुरूषाः)
७. (घ) १. दैत्या (च) for (दैत्याः) (ग) २. नंगुलार्द्ध for (मंडलार्द्ध)
३. मेखाद्यं for (मेषाद्यं) ४. मंसदा for (गंसदा)
(ङ) २. मपमंडलार्धं for (मपमंडलार्द्धं)
८. (घ) १. शशि (ग) शशि (च) (ङ) for (सशि)
२. स्वदिनम् (ङ) for (स्वदिवम्) (ङ) ३. वर्षार्धं for (वर्षार्द्धं)
९. (घ) १. चतुर्भागे (ग) तुर्य for (तूर्यभागै)
२. ऽवंती (ङ) (ग) लंकोत्तरोवन्ती for (लंकोत्तरतोवन्ती)
३. भगैः (ग) for (भागैः) (ग) ४. लंका for (लङ्का)
५. त्क्षिति for (क्षति) (च) १. चतुर्भागै for (तूर्यभागै)
२. ऽवन्ती for (वन्ती) (ङ) १. तुर्यभागे for (तूर्यभागै)
६. भूमस्तकात् for (भूमस्तका) ३. दशभागे for (दशभागैः)

अक्षांशभू[1]परिधि वधान्मंडलभागा स[2]योजनै विं[3]षुवत् ।
त[4]त्भाग योजनैरेवमुपरि[5]स्तयोन्य द[6]नुपातात् ॥ १० ॥
अंबरयोजनपरिधिः शशिभगणाः शून्यखखजिनाग्नि गुणाः[2] ।
यस्य भगणै वि[1]भक्तास्तत्क[3]क्षार्को[4]भषष्ट्यंशे ॥ ११ ॥
भू[3]परिधि समा[4]न षष्ट्या[5] ख[1] परिधि तुल्यानि कल्परविवर्षैः ।
गच्छंति योजनानि ग्रहाः स्वकक्षा[2]स्तु तुल्यानि ॥ १२ ॥
भग[2]णस्याधः शनिगुरु भूमिजरविशुक्र सौम्यचंद्रा[1]णाम् ।
क[3]क्षाक्रमेण शीघ्राः शनैश्चराद्याः कलाभुक्तया ॥ १३ ॥

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१०. (घ) १. कुपरिधि (ग) (च) (ङ) for (भूपरिधि) २. प्त (ग) (ङ) for (स)
३. विषुवत् (ग) (ङ) for (विंषुवत्) ४. नत (ग) (ङ) for (तत्)
५. सूर्योन्य (च) for (स्तयोन्य)
(ग) ६. दनुपात् for (दनुपातात्)
(च) २. भागाप्तयोजनै for (भागासयोजनै)
३. विषुवत् for (विंषुवत्) ४. नतभाग for (तत्भाग)
(ङ) (ङ) सूर्योऽन्य for (स्तयोन्य)

११. (घ) १. विभक्तस्तत् कक्षार्कोभ for (विभक्तास्तत् कक्षार्कोभ)
(ग) २. +३३२४०००+
(च) ३. कक्षार्क्कोभषष्ट्यंशे for (कक्षार्कोभषष्ट्यंशे)
(ङ) ३. कक्षाऽर्को for (कक्षार्को) ४. भषष्ठ्यंशः for (भषष्ट्यंशे)

१२. (घ) १. भ for (ख) २. स्वकक्षासू for (स्वकक्षास्तु)
(ग) ३. भपरिधि for (खपरिधि)
४. समानि (ङ) for (समान)
५. षष्टय for (षष्टया)
(च) ५. खष्टयाष for (षष्टया ख)
(ङ) २. स्वकक्षासु for (स्वकक्षास्तु)

१३. (घ) १. चंप्राणां for (चन्द्राणाम्)
(ग) २. भगणस्याधिः for (भगणस्याधः)
(ङ) ३. कक्षाः for (कक्षा)

लघवो[1]ल्पो राश्यंशा[2] महति महतो[3]ऽल्प[6]वृत्तमल्पेन[7] ।
पूरयंस्तींदुर्महता[4] कालेन महाशनैश्चारी[5] ॥१४॥
यन्मूलं तध्वासो[1] मंडललिप्ता कृतेर्दश[2]हतायाः ।
तस्यार्द्धं[3] व्यासार्द्धं[4] योजनकर्ण[5]प्रमाथार्थम्[6] ॥ १५ ॥
भगणकलाव्यासार्द्धं भवति कलाभिर्यतो[2] न सकलाभिः[3] ।
ज्यार्द्धानि न स्फुटानि[1] ततः कृतं व्यासदलमन्यत् ॥ १६ ॥
राश्यष्टांशे[1]ष्टांकांत्य[4]दसंधिभ्यः क्रमोक्रमाकृत्वा[2] ।
बध्नीयात् सुत्राणि[3] द्वयोर्द्वयो ज्यास्तिदर्द्धानि ॥ १७ ॥

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१४. (घ) १. लघवोऽल्पे for (लघवोल्पो) २. राशंशा (च) for (राश्यंशा)
३. महांतो (ग) (ङ) for (महतो)
४. पूरयतींदुर्म्महता (ग) पूरयतींदुर्महता (ङ) for (पूरयंस्तींदुर्महता)
५. महशनैश्चारी (ग) महछनैश्चारी (ङ) for (महाशनैश्चारी)
(ग) ६. ल्पवृत्त for (ऽल्पवृत्त) ७. मन्येन for (मल्पेन)
(च) ४. पूरयंती दुर्म्महता for (पूरयंस्तींदुर्महता)
५. महशनैश्चारी for (महाशनैश्चारी)
(ङ) १. लघवोऽल्पे for (लघवोल्पो)

१५. (घ) १. तद्व्यासो (ग) (ङ) for (तध्वासो) २. कृतेर्द्दश (ग) for (कृतेर्दश)
३. नस्यार्द्धं for (तस्यार्द्धं) ४. व्यार्द्धं for (व्यासार्द्धं)
५. कर्णमाणार्थम् (ग) (च) कर्ण प्रमाणार्थम् for (कर्ण प्रमाथार्थम्)
(च) १. तद्व्यासो for (तध्वासो) २. र्द्दशहतायाः for (र्दशहतायाः)
४. दयासार्द्धं for (व्यासार्द्धं)
(ङ) ६. प्रमाणार्थम् for (प्रमाथार्थम्)

१६. (घ) १.+(च)+(ङ)
(ग) २. र्यतोर्यतो for (र्यं तो न)
(ङ) ३. सविकलं हि for (सकलाभिः)

१७. (घ) १. ष्वंकान्पद (ग) for (शेष्टांकांत्यद)
२. क्रमोत्क्रमात्कृत्वा (ग) (ङ) for (क्रमोक्रमाकृत्वा)
३. सूत्राणि (ग) (च) (ङ) for (सुत्राणि)
(च) १. ष्वंकान्पद for (ष्टांकांत्यद) ग. क्रमोत्क्रम। कृत्वा for (क्रमोक्रमा कृत्वा)
(ङ) १. राश्यष्टांशेष्वङ्कान् for (राश्यष्टांशेष्टांकांत्)
४. पदसन्धिभ्यः for (यदसंधिभ्यः)

ज्यार्द्धानि ज्यार्द्धानां ज्याखंडान्यंतराणि तन्ये[1] च ।
व्यस्तान्यं[3] तदेथ विषुरु[2] क्रमज्या धनुस्ताभ्याम् ॥ १८ ॥
एक द्वित्रि[3] गुणाया व्यासार्द्ध क्रतेः[1] पृथक् चतुर्थेभ्यः ।
मूलान्यष्ट[4] द्वादश षोडष[2] षडान्यतो[5] न्यानि ॥ १९ ॥
तुल्यक्रमोक्रम[1] समज्या[6] खंडक[4] वर्ग युतिर्भगिम्[2] ।
प्रोह्यानष्टं[3] व्यासार्द्ध वर्गतस्तत्पदे[5] प्रथमं ॥ २० ॥
तद्दलखण्डानि तदुन[1] जिन समानि द्वितीयमुत्पत्तौ[2] ।
कृतयमलैक दिगीशेषु सप्तरसगुणा[3] नवादीनाम् ॥ २१ ॥
एवं जीवा खंडान्यल्पानि बहुनि[1] वाद्यखण्डानि[2] ।
ज्यार्द्धानि[3] वृत्तपरिधेः षष्टचतुर्थत्रिभागानाम् ॥ २२ ॥

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१८. (घ) १. तान्येव (ग) (ङ) (च) for (तन्ये च)
२. वेषु (ग) पादथतेषु for (विषुरूक्रमज्या)
(ग) ६. व्यस्तान्यत् for (व्यस्तान्यं) ३. व्यस्तान्यतादथ तेषु for (व्यस्तान्यं तदेथ विषु)
२. तेषुरुत्क्रमज्या for (विषुरुक्रमज्या)
(ङ) ३. व्यस्तान्यन्त्यादथ for (व्यस्तान्यं तदेथ)
२. वेषुरुत्क्रमज्या for (विषुरूक्रमज्या)
१९ (घ) १. क्रतेः (ग) (च) (ङ) for (कृतेः) २. षोडश (ग) (च) (ङ) for (षोडष)
(ग) ३. द्विगुणाया for (द्वित्रिगुणाया) ४. मूलात्यष्ट for (मूलान्यष्ट)
५. षंडान्यतो for (षडान्यतो)
(ङ) ५. खण्डान्यतोऽन्यानि for (षडान्यतोन्यानि)
२०. (घ) १. तुल्यकूमोत्कूम (ग) (च) (ङ) for (तुल्यकूमोकूम)
२. चतुर्भगिम् (ङ) for (र्भगिम्)
३. प्राज्यानष्टं (ग) प्राह्यानष्टं for (प्रोह्यानष्टं)
(ग) ४' खंड for (खंडक) ५. वर्ग्रस्तत्पदे for (वर्गतस्तत्पदे)
(च) ३. प्रोज्यानष्टं for (प्रोह्यानष्टं) (ङ) ६. ज्यासम for (समज्या)
२१. (घ) १. तदून (ग) (च) (ङ) for (तदुन)
(ग) २. (वि०—'द्वितीय' पद लुप्त है)
(च) ३. गुणनवादीनाम् (ङ) for (गुणानवादीनाम्)
२२. (घ) १. बहूनि (ग) (च) (ङ) for (बहुनि) २. षंडानि (च) for (खण्डानि)
(ग) ३. ज्यार्धनिवृत्तिपरिधेः for (ज्यार्द्धानिवृत्तपरिधेः)
(ङ) २. वाऽऽद्यखण्डानि for (वाद्यखण्डानि) ३. ज्यार्धानि for (ज्यार्द्धानि)

उक्रम[4] समखण्ड[5] गुणाढ्व्यासादथवा[1] चतुर्थभागाद्यम् ।
कृत्वोक्त खण्डकानि[2] ज्यार्द्धानयनं[6] नलध्वमस्मात्[3] ॥ २३ ॥
कक्षा[1]मंडल[2]भूमध्ये[3] मध्यमः स्वकक्षायाम् ।
अनुलोमं मंदोच्चात्प्रतिलोमं भ्रमति शीघ्रोच्चात् ॥ २४ ॥
त्यक्तं[1] तत्परिधौ प्रतिलोमं मन्दोच्चा भ्रमति शीघ्रोच्चात् ।
अनुलोमं मध्यस्थसमं[2] भूस्थः पश्यति यतोनकक्षायाम् ॥ २५ ॥

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२३. (घ) १. गुणाद्व्यासादथवा (ग) (च) (ङ) for (गुणाढ्व्यासादथवा)
२. षंडकानि (च) for (खंडकानि)
३. लघ्वस्मात् (ग) लघ्वमस्तात् for (लघ्वमस्मात्)
(ग) ४. उत्क्रम (च) (ङ) for (उक्रम) ५. खण्डा for (खण्ड)
६. यामार्द्धनयनं for (ज्यार्द्धानयनं)
(च) ३. नलघ्वमस्मात् for (नलध्वमस्मात्)
(ङ) ७. भागाद्यत् for (भागाद्यम्) ३. लघ्वस्मात् for (लघ्वमस्मात्)
२४. (घ) १. कक्ष्या for (कक्षा) २. मंडलमध्यं (ग) for (मडलभूमध्ये)
(च) १. कक्ष्या for (कक्षा) २. मंडलमध्यं for (मंडल)
(ङ) शी० + अथ स्फुट गतिवासना + ३. मध्यं भूमध्ये for (भूमध्ये)
२५. (घ) १. (वि०—यहाँ श्लोक की तीन पंक्तियाँ हैं।
"नीचोच्चवृत्तमध्यं मध्ये तद्भ्रमति मध्यमः स्वोच्चात्" (च) (ङ) for
(त्यक्तं तत्परिधौ प्रतिलोमं मंदोच्चा भ्रमति शीघ्रोच्चात्)
२. मध्यसमं (ग) (च) (ङ) for (मध्यस्थसमं)
(ग) १. "नीचोथवृत्तमध्यं मध्ये तद्भवति मध्यमः स्वोच्चात् ।"
तत्परिधौ प्रतिलोमं मंदोच्चात् भवति शीघ्रोच्चात् ॥ २५ ॥
for
(त्यक्तं तत्परिधौ प्रतिलोमं मंदोच्चा भ्रमति शीघ्रोचात् । अनुलोमं मध्यस्थसमं भूस्थः पश्यति यतो न कक्षायाम् ॥ २५ ॥)
(च) इस प्रति में 'घ' की भाँति श्लोक में तीन पंक्तियाँ हैं—पहली पंक्ति है :
—'नीचोच्चवृत्तमध्यं मध्ये तद्भ्रमति मध्यमः स्वोच्चात्"
(ङ) (वि०—इस प्रति की पहली पंक्ति 'नीचोच्चवृत्तमध्यं तद् भ्रमति मध्यगः स्वोच्चात्" उपर्युक्त प्रतियों में छूट गई। और दो श्लोकों की चार पंक्तियों में से केवल तीन को सम्मिलित करके एक श्लोक माना गया। आगे के श्लोकों में फलतः सर्वत्र इस प्रति की दृष्टि से पूर्व श्लोक का उत्तरार्ध + अग्रिम श्लोक का पूर्वार्ध मिलाकर श्लोकों की व्यवस्था की गई है।

स्पष्टं[1] तन्मध्यांतरमृणं धनं वा तप्तो[2] मध्ये ।
कोटिफलं व्यासार्द्धात्पदयोराद्यं तयो भवत्युपरि[3] ।। २६ ।।
द्वितृतीययोर्यतोऽधस्ताष्टक्तोनं[1] तरतः[2] कोटिः[3] ।
कर्णस्तद्भुजफलकृति[4]संयोग पदं तदुद्धृता त्रिज्या ।। २७ ।।
भुजफल[6] गुणिताप्तधनु गुणिते[1] चैवं[2] फलं शींघ्रे ।
त्रिज्या[3]भक्तः कर्णः परिधिगुणे[4] बाहुकोटिः[7] गुणाकारः[5] ।। २८ ।।

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२६. (घ) १. अष्टं for (स्पष्टं)
२. ततो (ग) गृहे मध्ये ।। २६ ।। for (तप्तो मध्ये)
३. भंवत्युपरि (ग) (च) (ङ) for (भवत्युपरि)
(ग) इस श्लोक की पहली पंक्ति २६ वें श्लोक की दूसरी पंक्ति है ।
इस श्लोक की दूसरी पंक्ति २७ वें श्लोक की पहली पंक्ति हैं—
(च) २. ततो for (तप्तो)
(ङ) दे० वि० नोट २५ वें श्लोक के अन्तर्गत टिप्पणी में ।
२. ग्रहे मध्ये for (तप्तो मध्ये)

२७. (घ) १. तद्युक्तोनं (ङ) for (ताष्टक्तोनं) २. ततः (ङ) for (तरतः)
(ग) ३. कोटिः ।। २७ ।। (ङ) for (कोटिः)
(वि०—इस श्लोक की दूसरी पंक्ति—२८ वें श्लोक की प्रथम पंक्ति है—
४. फलसंयोगं for (फलकृति संयोग)
(च) १. ऽधस्तद्युक्तोनं for (ऽधस्ताष्टक्तोनं)

२८. (घ) १. धनुर्गुणिते for (धनुगुणिते) (ग) गंणितेनैवं फलं शीघ्रे ।। २८ ।।
२. नैवं for (चैवं)
३. विज्या for (त्रिज्या)
४. गुणो (ग) (ङ) for (गुणे)
५. गुणकारः (ग) (ङ) for (गुणाकारः)
(ग) इस श्लोक की पहली पंक्ति २८ वें श्लोक की द्वितीय पंक्ति है ।
६. भुजफ for (भुजफल) ७. कोटि (ङ) for (कोटिः)
(च) १. गुंणिते for (गुणिते) ४. परिधोगुणो for (परिधिगुणे)
७. कोटि for (कोटिः) ५. गुणकारः for (गुणाकारः)
(ङ) १. धनुर्गणिते for (धनुगुणिते) २. नैवं for (चैवं)

असकृत्[1]मांदे तत्फलमाद्यसमं[3] नात्र कर्णो[4]स्मात् ।
प्रतिपादनार्थ[2]मुच्चं प्रकल्पितं ग्रहगतेस्तथा पातः ॥ २९ ॥
भुक्तेरूनाधिकना[1]मानस्यच्च भवति कर्णव[2]शात् ।
कक्ष्या[3] व्यासार्द्धगुणा मंडललिप्ता विभाजिताकर्णः ॥ ३० ॥
स्वकलाकर्णेन गुणः कर्णस्त्रिज्याहृतः[1] स्पष्टः ।
मद्दहन[2] जलमयानं[4] विष्कंभा[5] योजनैः कनेंदुना[3] ॥ ३१ ॥

२९. (घ) १. असकृन्मां (ग) असकृन्मांद्ये for (असकृत् मांदे)
२. प्रतिपदेनार्थमुच्चं for (प्रतिपादनार्थमुच्चं)
(ग) ३. सम for (ममं)
४. कर्णोस्मात् ॥ २९ ॥ (ङ) for (कर्णोस्मात्)
इस श्लोक का उत्तरार्ध, ३० वें श्लोक का पूर्वार्ध है ।
(च) १. असकृन्मांदे for (असकृत्मांदे)
४. कर्णोस्मात् for (कर्णोस्मात्)
(ङ) २. असकृन्मान्दे for (असकृत्मांदे)
३०. (घ) १. तामानस्य (ग) for (नामानस्य)
(ग) २. व स्यात् ॥ ३० ॥ for (वशात्)
३. कक्षा (ङ) for (कक्ष्या)
इस श्लोक का उत्तरार्ध, ३१ वें श्लोक का पूर्वार्ध है ।
(च) १. तामानस्य for (नामानस्य)
(ङ) १. रूनाधिकता for (रूनाधिकना)
४. +इति स्फुटगतिवासना+
३१. (घ) १. हृतः (ग) हृतस्पष्टः ॥ ३१ ॥ for (हृतः)
२. मृद्दहन (ग) (ङ) for (मद्दहन)
३. क्निनेन्दूनाम् (ग) केनेदूनाम् for (कनेंदुना)
(ग) ४. मायानां for (मयानं)
इस श्लोक की दूसरी पंक्ति अगले श्लोक की पहली पंक्ति है ।
(च) हृतः for (हृतः)
२. मृद्दहन (ङ) for (मद्दहन)
४. जलमयानां (ङ) for (जलमयानं)
३. क्निनेंदुनां for (कनेंदुना)
(ङ) ५. विष्कंभो for (विष्कंभा)
३. द्विनेंदूनां for (कनेंदुना)

शशिवसुतिथिभि[6] यमपक्षशररसैः[1] शून्य वस्तु[2] वेदैः ।
व्यर्क[3] व्याप्तांतर[4] गुणमिंदु स्फुट कर्णमर्ककर्णहृतम्[5] ।। ३२ ।।
प्रोहृच भुवो भुछाया[1] विष्कंभश्चंद्रकक्षायाम्[2] ।
तद्गुणितं व्यासार्द्धं शशिकर्णहृतं ततः[3] प्रमाणकलाः ।। ३३ ।।
एवं त्रिज्या[1] रविशशि विष्कंभगुणाः[6] स्वकर्णहृताः[2] ।
भूछायेन्दुश्चंद्र[4]सूर्य[3] छादयति मानयोगार्द्धात् ।। ३४ ।।[5]

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३२. (घ) १. यँम (ग) यमपक्षरासैः ६५२२ for (यमपक्षशररसैः)
२. वसु (ग) वसुवेदैः (ङ) for (वस्तुवेदैः)
३. क्कर्क for (व्यर्क) ४. व्यासांतर (ग) for (व्याप्तांतर)
५. हृतम् (ग) for (हृतम्)
(ग) ६. राशिवसुतिथिभिः १५८१ for (शशिवसुतिथिभिः)
(वि०—इस श्लोक के पूर्वार्ध की समाप्ति पर ३२ संख्या होनी चाहिए परन्तु लिखी हुई ३३ है)
(च) १. यँम for (यम) २. वसु for (वस्तु)
३. व्यर्क्क for (व्यर्क) ४. व्यासांतर for (व्याप्तांतर)
५. मर्क्ककर्णहृतं for (मर्ककर्णहृतम्)
(ङ) १. यँम for (यम)
३३. (घ) १. भूछाया (ग) for (भुछाया)
२. कक्ष्यायाम् (ग) कक्षायाम् ।। ३४ ।। for (कक्षायाम्)
३. तमः (ग) (च) (ङ) for (ततः)
(ग) इस श्लोक का उत्तरार्ध अगले श्लोक का पूर्वार्ध है ।
(च) १. प्रोज्यभुवोभूछाया for (प्रोह्यभुवोभुछाया)
(ङ) १. भूच्छाया for (भुछाया)
३४. (घ) १. तृज्याशशि for (त्रिज्यारविशशि) २. हृताः (ग) हृता ।।३५।। for (हताः)
३. सूर्यं (ग) (च) (ङ) for (सूर्य)
४. भूछायेंदु चंद्रः (ग) भूछायेंदूचंद्रः for (भूछायेन्दुश्चंद्र)
५. (वि०—यहां पर कोई अंक संख्या नहीं दी)
(ग) ६. गुणः for (गुणाः)
(वि०—इस श्लोक का उत्तरार्ध ३६ वें श्लोक का पूर्वार्ध है)
(च) २. हृताः for (हताः) ४. भूछायेंदुचंद्रः for (भूछायेंदुश्चन्द्र)
५. (वि०—यहां पर क्रमसंख्या लुप्त है)
(ङ) ४. भुच्छायेंदु चन्द्रः for (भूछायेंदुश्चन्द्र) ६. गुणा for (गुणाः)

विक्षेपो[६] यद्यूनः शुक्लेतर पंच[३] दृश्यंते[१] ।
महदिदो[७] रावणं[४] कुठ[५] विषाणो यतो[२] संछन्नः[८] ।। ३५ ।।
अर्द्धछिन्नो[५] भानुस्तिक्षरण[१] विषाणस्ततो स्याल्पे[२] ।
यदि राहुः प्राग्भादिंदु[३] छादयति किं तथा नार्कम्[४] ।। ३६ ।।

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३५. (घ) १. दश्यंते (ङ) for (दृश्यन्ते)
(यहां ३५ की संख्या अङ्कित है)
२. द्धं संछन्नः (ग) र्धसंछन्नः (ङ) ऽर्ध सञ्छन्नः for (संछन्नः)
(ग) ३. पंचं for (पंच)
१. दिश्यंते ।।३६।। for (दृश्यंते)
४. रादरणं for (रावणं)
५. कुठ (ङ) for (कुठ)
वि०—इस श्लोक का उत्तरार्ध ३७ वें श्लोक का पूर्वार्धं है)
(च) ६. विक्ष्येपो for (विक्षेपो)
३. पंदृश्यंते ३५ for (पंचदृश्यंते)
७. महदिदो (ङ) for (महदिदो)
२. यतोर्द्धं for (यतो)
८. (वि०—यहां कोई क्रमसंक्या अंकित नहीं है)
(ङ) ४. रावरणं for (रावणं)

३६. (घ) १. स्तीक्ष्ण (ग) (ङ) for (स्तिक्षरण)
२. ततोऽस्याल्पम् (च) (ङ) for (ततोस्याल्पे)
(वि०—यहां क्रमसंख्या ३६ दी है)
३. प्राग्भागादिंदु (ग) प्राग्भादिंदुं for (प्राग्भादिंदु)
(ग) २. ततोऽस्याल्पी ।।३७।। for (ततोस्याल्पे)
(वि०—इस श्लोक का उत्तरार्धं ३८ वें श्लोक का पूर्वार्धं है)
(च) १. स्तीक्ष्ण for (स्तिक्षरण)
४. (वि०—यहां कोई क्रमसंख्या नहीं दी, क्योंकि इस प्रति के अनुसार यहां का उत्तरार्धं ३७ वें श्लोक का पूर्वार्धं है।
(ङ) ५. अर्धच्छन्तो for (अर्द्धछिन्नो)
२. प्राग्भागादिन्दुं for (प्राग्भादिंदु)

स्थित्यर्द्धं[1] महदिन्दो यथा[5] तथा किन्न सूर्यस्य[2] ।
किं प्रतिविषयं[3] सूर्योराहुश्चान्यो[4] यतो रविग्रहणे ।। ३७ ।।[6]
ग्रासान्यत्वं न ततो राहुक्र्तं[1] ग्रहण मर्कंद्वोः[2] ।
एवं वराहमिहिरश्रीषेणार्य[3]भटविष्णुचंद्राद्यैः ।। ३८ ।।[4]
लोक विरूद्धमभिहितं वेदस्मृति[1]संहिताबाह्यम्[4] ।
यद्येवं[5] ग्रहणफलं गर्गाद्यैः संहितामु[2]दयभिहित[3]म् ।। ३९ ।।

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३७. (घ) १. स्थित्यद्धं for (स्थित्यर्द्धं)
२. सूर्यः स्य (यहां क्रमसंख्या ३७ दी है) (ग) सूर्यस्य ।।३८।। for (सूर्यस्य)
३. विषग्रं (ग) विखयं for (विषयं)
(ग) (वि०—इस श्लोक का उत्तरार्ध ३९ वें श्लोक का पूर्वार्ध है ।
४. सूयो for (सूर्यो)
(च) ५. यंथा (ङ) for (यथा)
२. (वि०— यहां क्रमसंख्या ३७ अंकित है)
६. वि०—यहां कोई क्रमसंख्या नहीं दी है, क्योंकि इस श्लोक का उत्तरार्ध, ३९ वें श्लोक का पूर्वार्ध है । (ङ) १. स्थित्यर्धं for (स्थित्यर्द्धं)

३८. (घ) १. कृतं (ग) (च) (ङ) for (क्रतं)
२. मर्कंद्वोः (ग) मर्कंद्वोः ।।३९।। for (मर्कंद्वो) (यहां ३८ संख्या दी है)
(ग) ३. श्रीषेणाचार्यं for (श्रीषेणार्यं)
इस श्लोक का उत्तरार्ध, ४० वें श्लोक का पूर्वार्ध है ।
(च) २. मर्क्कंद्वोः for (मर्कंद्वो.) (वि०—यहां श्लोक संख्या ३८ अंकित है)
४. यहां क्रमसंख्या लुप्त है, क्योंकि यह ३९ वें श्लोक का पूर्वार्ध है ।
(ङ) २. मर्केन्द्वोः for (मर्कंद्वोः)

३९. (घ) १. स्त्रिम्मृवि for (स्मृति) (यहाँ संख्या ३९ है)
२. संहितासु (ग) (ङ) for (संहितामु)
३. यदि भिहितम् (ग) for (दयभिहितम्)
(ग) ४. संहिताद्वाह्यम् ।। ४० ।। for (संहिताबाह्यम्)
५. यद्येव ग्रहफलं for (यद्येवं ग्रहणफलं)
(वि०—इस श्लोक का उत्तरार्ध ४१ वें श्लोक का पूर्वार्ध है ।
(च) ४. यहाँ '३९' की क्रमसंख्या अंकित है । परन्तु उत्तरार्ध के अन्त में कोई क्रमसंख्या अंकित नहीं, क्योकि उत्तरार्ध, ४० वें श्लोक का पूर्वार्ध माना जाता है ।
(ङ) ३. यदभिहितम् for (दयभिहितम्)

तदभावे[2] होमजपः[3] स्नानादि[4] फलस्य[5] चाभावः।[7]
राहुकृतं[1] ग्रहणद्वय मागोपालांगनादि[2] सिद्धमिदम् ॥ ४० ॥[8]
बहुफलमिदमपि[1] सिद्धं जपहोमस्नानफलमत्र[2]।
स्मृतीषुक्तं[3] न स्नानं राहोरन्यत्र दर्शनाद्रात्रौ ॥ ४१ ॥
राहुग्रस्ते सूर्ये[1] सर्वं गंगासमं तोयम्[2]।
स्वर्भानुरास्तुरिरिनं[3] तमसा वित्याधवेदवाक्यमिदम्[4] ॥ ४२ ॥

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४०. (घ) (वि०—यहाँ प्रथम पंक्ति के अन्त में ४० संख्या दी है)
१. कृतं (ग) for (कृतं)
(ग) २. तदभावो for (तदभावे) ३. लुप्त पद है। ४. लुप्त पद है।
५. फलस्याभावः ॥ ४१ ॥ for (फलस्य चाभावः)
(वि०—इस श्लोक का उत्तरार्ध, अगले श्लोक का पूर्वार्ध है)
६. माग्गो पालाऽगना for (मागो पालांगनादि)
(च) ७. यहाँ '४०' क्रमसंख्या अंकित है। ८. यहाँ कोई संख्या अंकित नहीं, क्योंकि यह उत्तरार्ध भाग ४१ वें श्लोक का पूर्वार्ध माना जाता हैं।
(ङ) ४. जप for (जपः) ५. स्नानादीनां फलाभावः for (स्नानादि फलस्य चाभाव)

४१. (घ) १. बाहु for (बहु)
२. मंत्र (यहाँ क्रमवंख्या ४१ दी है) (ग) मत्र ॥ ४२ ॥ for (मत्र ॥ ४१ ॥)
३. स्मृतिषूक्तं (ग) (ङ) for (स्मृतीषुक्तं)
(ग) इस श्लोक का उत्तरार्ध ३३ श्लोक का पूर्वार्ध है
(च) २. यहाँ '४१' क्रमसंख्या दी गई है। ३. स्मृतीषूक्तं for (स्मृतीषुक्तं)
(वि०—इस प्रति के अनुसार इस श्लोक का उत्तरार्ध ४२ वें श्लोक का पूर्वार्ध है अतः यहाँ अन्त में क्रमसंख्या अंकित नहीं है)

४२. (घ) १. सूर्ये (ग) (च) (ङ) for (सूर्ये)
२. (वि०—यहाँ क्रमसंख्या ४२ (ग) ४३ दी है)
३. रासुरि (ग) रासुरि न तमसा for (रास्तु)
४. विच्याध (ग) विव्याध (ङ) for (वित्यधा)
(ग) इस श्लोक का उत्तरार्ध अगले श्लोक का पूर्वार्ध है।
(च) २. (वि०—यहाँ क्रमसंख्या ४२ अंकित है) ३. रासुरिरिन for (रास्तुरिरिनं)
४. विव्याध for (वित्याध)
यहाँ श्लोक के अन्त में कोई क्रमसंख्या अंकित नहीं क्योंकि यह उत्तरार्ध माना जाता है।
(ङ) ३. रासु for (रास्तु)

श्रुतिसंहितास्मृतीनां भवति तथैक्यं[1] तदुक्तिरतः[3] ।[2]
राहुस्तच्छादयति प्रविशति यच्छुक्ल पंच दश्यन्ते[4] ।। ४३ ।।
भूछाया तमसींदो[4] वंरप्रदानात्कमलजस्य[5] ।[1]
चन्द्रोवुभयोधस्थो[2][3] यदग्निमय[6] भास्करस्य मासांते ।। ४४ ।।
छादयति शमिततयो[3] राहु छादयति[6] तत्सवितुः[4] ।[1]
भूछाया व्याससमः[2] शशिकक्षायां स्थितः शशिग्रहणे ।। ४५ ।।[5]

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४३. (घ) १. यथैक्य (ग) (च) (ङ) for (तथैक्य)
२. (वि०—यहाँ क्रमसंख्या ४३ दी है) (च) (ङ)
(ग) ३. रंतः ।। ४४ ।। for (रतः)
४. यत् शुक्ल पंच दृश्यंते for (यच्छुक्ल पंचदश्यन्ते)
(च) (वि०—यहाँ इस श्लोक के अन्त में कोई क्रमसंख्या अंकित नहीं क्योंकि यह उत्तरार्ध यहाँ ४४ वें श्लोक का पूर्वार्ध माना जाता है)
(ङ) ४. यच्छुक्ल for (यच्छुक्ल)

४४. (घ) १. (वि०—यहां क्रमसंख्या ४४ दी है) (च) (ङ)
२. वुमयो (ग) चंद्रोबुमयोधस्थः for (चन्द्रोवुभयोधस्थो)
३. घस्थो for (ऽधः स्थो)
(ग) ४. नभसींदो for (तमसींदो)
५. त्कमलाया ने ।।४४।। for (कमलजस्य). ६. यदग्नियम for (यदग्निमय)
(वि०—इस श्लोक का उत्तरार्ध ४५ वें श्लोक का पूर्वार्ध है)
(च) (वि०—इस श्लोक का उत्तरार्ध ४५ वें श्लोक का पूर्वार्ध है) अतएव यहां अन्त में कई क्रमसंख्या अंकित नहीं ।
(ङ) ५. कमलयोनेः for (कमलजस्य)
२. छन्द्रोऽम्बुमयोऽधः स्थो for (चन्द्रोवुभयोधस्थो)

४५. (घ) १. (वि०—यहां क्रमसंख्या ४५ अंकित है) (च) (ङ)
२. सम for (समः)
(ग) ३. शमिततापो (ङ) for (शमिततयो)
४. तच्छवितुः ।।४५।। for (तत्सवितुः)
(वि०—इस श्लोक का उत्तरार्ध, ४६ वें श्लोक का पूर्वार्ध है) (च)
(च) ३. शमितताये for (शमिततयो) ५. क्रम संख्या लुप्त
(ङ) ६. राहुश्छादयति for (राहुछादयति)

राहु छादयतींदु सूर्यग्रहणेर्कमिंदु समः ।
यत्तदधिकं तमोमयराहुव्यासस्य सूर्य द्रष्टं तत् ॥ ४६ ॥
नश्यति भूछायेंदु व्यास समोस्माद् भवति राहुः ।
भूछायानेंदुमतो ग्रहणे छादयति नार्कबिंदुर्वा ॥ ४७ ॥
तत्स्थस्तध्व्याससमो राहु छादयति शशिसूर्यौ ।
प्राच्यपरं सममंडलमन्यद्याम्योत्तरं क्षितिजमन्यत् ॥ ४८ ॥

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४६. (घ) १. मिंदुं समः (ग) (च) (for मिंदुसमः)
(वि०—यहां क्रमसंख्या ४६ अंकित है)
२. दृष्टं तत् (ग) for (द्रष्टं तत्)
(ग) ३. छादयतींदुं for (छादयतींदु) ४. सूर्यं for (सूर्य)
५. 'सूर्य' लुप्त पद है ।
(वि०—श्लोक का उत्तरार्ध ४७ वें श्लोक का पूर्वार्ध है) (च)
(च) २. दृष्टं for (द्रष्टं) ६. क्रमसंख्या लुप्त
(ङ) ३. राहुश्छादयतीन्दुं for (राहुछादयतीन्दु) २. दृष्टत्वात् for (दृष्टंतत्)
४७. (घ) १. समोऽस्माद् (च) for (समोस्माद्)
(वि०—यहां क्रमसंख्या ४७ दी है)
२. भूछाययेंदु for (भूछायानेंदुमतो)
(ग) ३. राहुः ॥४७॥ for (राहुः)
४. मिंदुर्वा for (बिंदुर्वा)
(वि०—इस श्लोक का उत्तरार्ध, ४८ वें श्लोक का पूर्वार्ध है) (च)
(च) २. भूछायातेंदुमतो for (भूछायानेंदुमतो) ४. नार्क्कंमिंदुवति for (नार्कबिंदुर्वा)
५. क्रम संख्या लुप्त
(ङ) ६. भूछायेन्द्वोर्व्यास for (भूछायेंदुव्यास)
२. भूछायेन्दुमतो for (भूछायानेंदुमतो)
४८. (घ) १. तद्व्यास (ग) (ङ) for (तध्व्यास) २. राहुं for (राहु)
३. (वि०—यहां क्रमसंख्या ४८ अंकित है) (च)
(ग) ३. सूर्यैः ॥४८॥ for (सूर्यौ)
(वि०—इस श्लोक का उत्तरार्ध ४९ वें श्लोक का पूर्वार्ध है) (च)
(च) १. श्छस्तद्व्यास for (तत्स्थस्तध्व्यास) ४. क्रमसंख्या लुप्त
(ङ) (वि०—प्रथम पंक्ति समाप्ति पर 'ग्रहण वासना' समाप्त)
+अथगोलबन्धाधिकारः+आरम्भ ।
२. राहुश्छादयति for (राहुछादयति)

परिकरवत्तन्मध्ये भूगोलस्थितद्रष्टुः[१] ।
पूर्वापरयोर्लग्नं याम्योत्तरयोर्न्नतोन्नतं[२] क्षितिजात् ॥ ४६[३] ॥
स्वाक्षांशै[५]रुन्मंडल[१]महर्निशो वृ[६]द्धिहानिकरम्[२] ।
विषुवन्मंडलमूर्द्धं सममंडल[३]स्थितं स्वकक्षांशैः[४] ॥ ५०[७] ॥
याम्येनो[२]त्तरतोधः क्षितिजे[३] प्राच्यपरयो लग्नम्[१] ।
विषुवन्मंडललग्नं मेषतुलावावुद[४]कुलीरादौ ॥ ५१[५] ॥

४६. (घ) १. भूगोलस्तस्थित द्रष्टुः (ङ) for (भूगोलस्थितद्रष्टुः)
(वि०—यहां कोई क्रमसंख्या नहीं दी गई) (च)
(ग) १. स्थस्थितद्रष्टुः ॥४६॥ for (स्थितद्रष्टुः)
२. याम्योत्तरयोर्नतं क्षितिजात् for (याम्योत्तरयोर्न्नतोन्नतं क्षितिजात)
(वि०—इस श्लोक का उत्तरार्ध ५० वें श्लोक का पूर्वार्ध है) (च)
(च) १. स्तस्थित for (स्थित) ३. क्रमसंख्या लुप्त ।

५०. (घ) १. रुन्मंडल (ग) for (रुन्मंडल)
२. (वि०—यहां क्रमसंख्या ५० दी हुई है) (ग) (च)
३. मंडलः (ग) मंडलवत्स्थितं for (मंडलस्थितं)
४. स्वकक्षोंशैः for (स्वकक्षांशैः)
(ग) ५. स्वक्षांशैः for (स्वाक्षांशै)
(वि०—इस श्लोक का उत्तरार्ध, ५१ वें श्लोक का पूर्वार्ध है) (च)
(च) ३. सममंडलः for (सममंडल) ७. क्रमसंख्या लुप्त
(ङ) ६. महर्निशोर्हानिवृद्धिकरम् for (महर्निशोर्वृद्धिहानिकरम्)
३. सममंडलतः for (सममंडल)
४. स्वकाक्षांशै for (स्वकक्षांशैः)

५१. (घ) १. (वि०—यहां क्रमसंख्या ५१ दी है) (ग) (च)
(ग) २. याम्यो for (याम्ये) ३. क्षितिज for (क्षितिजे)
४. रकुलीरादौ for (कुलीरादौ)
(वि०—इस श्लोक का उत्तरार्ध ५२ वें श्लोक का पूर्वार्ध है) (च)
(च) ४. वुदत्कुलीरादौ for (वुदकुलीरादौ) ५. क्रमसंख्या लुप्त ।
(ङ) २. याम्येनोत्तरतोऽधः for (याम्येनोत्तरतोधः)
४. वुदक् कुलीरादौ for (वुदकुलीरादौ)

जिन[५]भागैर्यम्येन[१] मृगादावपमंडलमिहार्कः।[२]
पातश्चंद्रादिनां[३] भ्रमंति[६] भार्द्धे[४] खेश्च भूछाया ॥ ५२ ॥[७]
पातदयमंडल[१] वह्नि मंडलानि[३] स्वविक्षेपैः।[२]
सौम्यं विमंडलार्द्धं प्रथमं याम्यं द्वितीयमेतेषु[४] ॥ ५३ ॥[५]
चन्द्रकुज जीवमंदा भ्रमंति शीघ्रेण बुधशुक्रौ।[१]
दृग्मंडलार्द्ध मूर्द्धं[३] यत्तत्परिधि स्थितं ग्रहं द्रष्टाः[२] ॥ ५४ ॥[४]
पश्यति यतः क्षितिस्थस्तद्भ्रमति[२] ततो ग्रहाभिमुखं।[१]
क्षितिजापमंडलयुतिर्लग्नं लग्नाग्रतो[३] दिशंवलनं[५] ॥ ५५ ॥[४]

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५२. (घ) १. यंमोन for (यम्येन)
२. (वि० – यहां क्रमसंख्या ५२ दी हुई है) (ग) (च)
३. पाताश्चंद्रादीनां (ग) (ङ) for (पातश्चन्द्रादिनां)
४. भार्द्ध for (भार्द्धे) (ग) ५. निज for (जिन)
६. भ्रमंते for (भ्रमंति)
(वि०—इस श्लोक का उत्त रार्ध ५३ वें श्लोक का पूर्वार्ध है) (च)
(च) ३. पाताश्चंद्रादीनां for (पातश्चंद्रादिनां) ७. क्रमसंख्या लुप्त
५३. (घ) १. पातादषमंडल (ग) पातादपमंडलवत् for (पातदयमंडलवद्)
२. (वि०—यहां क्रमसंख्या ५३ दी है) (ग) (च)
(ग) ३. विमंडलानि for (द्विमंडलानि)
(वि०—इस श्लोक का उत्तरार्ध ५४ वें श्लोक का पूर्वार्ध है) (च)
४. द्वितीयामातष्ट for (द्वितीयमेतेपु)
(च) १. पातदपमंडल for (पातदयमंडल) ५. क्रमसंख्या लुप्त
(ङ) १. पातादपमंडलवद् for (पातदयमंडलवद्)
५४. (घ) १. (वि०—यहां क्रमसंख्या ५४ दी है) (ग) (च)
२. द्रष्टा (ग) दृष्टा for (द्रष्टाः) (ग) ३. भूर्द्ध for (मूर्द्धं)
(वि०—इस श्लोक का उत्तरार्ध ५५ वें श्लोक का पूर्वार्ध है) (च)
(च) २. द्रष्टा for (दृष्टाः) ४. क्रमसंख्या लुप्त
(ङ) ३. मूर्ध्वं for (मूर्द्धं) २. द्रष्टा for (द्रष्टाः)
५५. (घ) १. (वि०—यहां क्रमसंख्या '५५' दी गई है) (ग) (च)
(ग) २. तद्रमति for (तद्भ्रमति) ३. यादिशं for (तोदिशं)
(वि०—इस श्लोक का उत्तरार्ध ५६ वें श्लोक का पूर्वार्ध है) (च)
(च) ४. क्रमसंख्या लुप्त (ङ) ३. लग्नाग्रया for (लग्नाग्रतो)
५. दिशा लग्नम् for (दिशंवलनं)

हृक्षेपं[2] मंडलं दक्षिणोत्तरं[3] वित्रिभ[1] विलग्नम्[4] ॥ ५६ ॥
विषुवदुदग्बध्नीया[3] क्रन्त्यांशसमांतरेष्वजादीनाम्[1] ।
वृत्ततृतीयं[4] व्यस्तं कर्कादीनां[2] तुलादीनाम् ॥ ५७ ॥
विषुवद्दक्षिणतो[3] न्यन्मकरादीनां तदेव विपरीतम् ।
स्वाहोरात्रान्येषां[1] व्यासा[4] पृगवेव[2] भिन्नमपि ॥ ५८ ॥
लंका समपश्चिमगं प्राणेन कला[1]भूमंडलं[3] भ्रमति ।
अपमंडलस्यराशिर्द्वादशभागाः[4] क्षितिजलग्नाः[2] ॥ ५९ ॥

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५६. (घ) १. तृभ विलग्ने (ग) for (वित्रिभविलग्नम्)
(ग) २. हृक्षेपमंडलं for (हृक्षेपं मंडलं)
३. दक्षणोत्तरं for (दक्षिणोत्तरं)
(च) २. हृक्षेपमंडलं for (हृक्षेपं मंडलं)
४. विलग्ने for (विलग्नं)
(ङ) २. हृक्क्षेपमंडलं for (हृक्षेपं मंडलं)
१. वित्रिभविलग्ने for (वित्रिभ विलग्नम्)

५७. (घ) १. क्रांत्यंश (ग) (च) (ङ) for (क्रन्त्यांश)
२. कर्क्यादीनां (ङ) for(कर्कादीनां)
(ग) ३. विषविदुदग्बध्नीयात् for (विषुवदुदग्बध्नीया)
४. वृत्तत्रितयं (ङ) for (वृत्ततृतीयं)
(च) २. कक्कादीनां for (कर्कादीनां)
(ङ) ३. विषुबदुदग्बध्नीयात् for (विषुवदुदग्बध्नीया)

५८. (घ) १. रात्राण्येषां (ग) (च) (ङ) for (रात्रान्येषां)
२. पृथगेव (ग) (ङ) for (पृगवेव)
४. व्यासाः (ङ) for (व्यासा)
(च) २. पृथगेव for (पृगवेव)
(ङ) ३. दक्षिणतोऽन्यन् for (दक्षिणतोन्यन्)

५९. (घ) १. कलां (ग) (ङ) for (कला)
२. जलग्नः for (जलग्नाः)
(ग) ३. भमंडनं for (भूमंडलं) ४. भाग for (भागाः)
(ङ) ३. भमण्डलं for (भूमण्डलं) ४. भागः for (भागाः)

यात्यूदयं[1] मेषाद्या यत[2]स्तत[5]स्तदुदया[3]नकालसमाः ।
क्रांतिवशाल्लंकायां[4] तद्वनताधिक्यमक्ष[6]वशात् ।। ६० ।।
क्षितिजोन्मंडलयोर्यत्[3]स्वाहो[1]रात्रांतरं चरदलं तत् ।
क्षितिजेऽग्रा[4]प्राच्यपर[2] स्वाहोरात्रांतरांशज्या ।। ६१ ।।
स्वाहोरात्रे क्षितिजाद्[1] दिनगतशेषो[2]न्नतारवेः[3] शंकुः ।
तस्माद्[5] दिनगतशेषं शंकु कुमध्यांतरं[4] दृग्ज्या ।। ६२ ।।
दृग्मंडले[1] नतांशज्या दृग्ज्या शंकुरून्नतांशज्या ।
अर्को[5]दयास्तसूत्रा[3]दिनशंको[2]र्दक्षिणे[4] नृतलम् ।। ६३ ।।
क्षितिजे भू[2]दललिप्ताः कक्षायां[3] दृग्गतिनभो मध्यात् ।
अवनति लिप्ता याम्योत्तरार[1]र्क[4] ग्रहवदन्यतः ।। ६४ ।।

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६०. (घ) यांत्युदयं (ग) यात्युदयं (च) for (यात्यूदयं) २. ग्रत for (यत)
३. 'न' यहाँ लुप्त है ४. ल्लंकायां (ग) (ङ) for (लंकायां)
(ग) ५. 'ततस्' पद लुप्त है ६. मज्ञ for (मक्ष)
(च) ४. ल्लंकायां for (लंकायां)
(ङ) १. यान्त्युदयं for (यात्यूदयं) ५. तदुदया for (ततस्तदुदया)
६१. (घ) १. रात्रेतरं for (रात्रांतरं) २. रपस्वाहो for (परस्वाहो)
(ग) ३. यत for (यंत्) (च) १. रात्रेतरं for (रात्रांतरं)
(ङ) ४. क्षितिजेऽग्रा for (क्षितिजेग्रा)
६२. (ग) १. जात्दिन for (जाद्दिन) २. श्च for (च्च)
३. ताखे for (तारवे) ४ 'दृग्ज्या' पद लुप्त । यहाँ···कुछ अंश छूटा हुआ है
(च) ५. तस्मा दिनगत for (तस्माद्दिनगत)
(ङ) १. जितिजाद्दिन for (क्षितिजाद्दिन)
६३. (घ) १. दृग्मंडले (ग) दृग्मंडल for (दृग्मंडले)
२. शकोर्दक्षिणेन (ङ) (च) for (शंकोःर्दक्षिणेन्)
(ग) ३. सूत्रान् for (सूत्रादिन) ४. र्दक्षिणानतलम् for (र्दक्षिणेनृतलम्)
(च) ५. अर्क्कादयास्त for (अर्कोदयास्त)
(ङ) ३. सूत्राद्दिन for (सूत्रादिन)
६४. (घ) १. स्युरर्क (ग) रविग्रहवदन्यत् ।। ६५ ।। for (रर्कग्रहवदन्यतः)
(ग) (वि०—इसकी क्रमसंख्या ६५ है) २. 'भू' लुप्त है) ३. दृक्नति for (दृग्गति)
(च) ३. दृग्गतिन्नभोमध्यात् for (दृग्गतिनभोमध्यात्)
(ङ) ३. दृङ्नतिर् for (दृग्गति) १. रवि for (रर्क) ४. वदन्यत्र for (वदन्यतः)

दृश्या[१]दृश्यं दृग्गोला[२]र्द्धं भूव्यासदलवि[३]हीन[४]युतम् ।
[५]दृष्टाभूगोलोपरि यतस्ततो लंबनावन[६]ति ।। ६५ ।।
सत्रिग्रह[१] क्रांति[५]रूदग्दक्षिणयोस्त्रिज्यया हृ[२]तं वलनम् ।
विक्षेप[६]गुणमृणधनं ग्रहे[३]न्य[४]दृक्कर्म्म चरदलवत् ।। ६६ ।।
[१]कक्षामंडलतुल्यं प्रा[२]च्यपरं दक्षिणोत्तरं क्षिति[३]जम् ।
उन्मंडलविषुवन्मंडले स्थिराणि ग्रहर्क्षाणाम् ।। ६७ ।।
मंदो[१]च्याना सप्तोच्चनीच वृत्तानि पंचशीघ्राणाम् ।
प्रतिमंडलानि चैवं प्रत्ये[२]कां भास्करादीनाम् ।। ६८ ।।
[५]दग्मंडल[१]दग्क्षेपापमन्डलानि क्ष[६]पाकरादीनाम् ।
षट्कं विमण्डला[२]न्यं चलवृ[३]त्यानेक पंचाशत्[४] ।। ६९ ।।

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६५. (घ) १. दृश्यो for (दृश्यादृश्यं)
(ग) (वि०—इसकी क्रमसंख्या ६४ है)
२. गोलार्द्ध for (दृग्गोलार्द्ध) ३. विहीनम् for (विहीन)
४. दृष्टो for (दृष्टा) (वि०—दूसरी पंक्ति 'भूगोल' से आरम्भ है)
५. 'दृष्टा' लुप्त है ६. नती ।।६४।। for (नति ।।६५।।)
(च) २. दृग्गेलार्द्ध for (दृग्गोलार्द्ध)
(ङ) (वि०—यह श्लोक उपलब्ध नहीं)
६६. (घ) १. ग्रह् (च) (ङ) for (ग्रह) २. हृतं (च) (ङ) for (हृतं)
३. गृहे (च) for (ग्रहे) ४. न्यदृक्कर्मं (ग) (ङ) for (न्यदृकर्म)
(गं) ५. रुदक् for (रूदग्) ६. गुणाधनं for (गुणमृणधनं)
६७. (ग) १. कक्ष्या for (कक्षा) २. प्राक्परं for (प्राच्यपरं)
३. क्षिजम् for (क्षितिजं)
६८. (घ) १. मंदोच्चानां (ग) (च) (ङ) for (मंदोच्याना)
(ग) २. प्रत्येकं (च) for (प्रत्येकां)
६९. (घ) १. दृक्षेपाप (ग) विक्षेपाप) (ङ) for (दग्क्षेपाप)
२. विमंडलानां (ग) (ङ) for (विमंडलान्यं)
३. वृत्तान्येक (ग) वलवृत्तान्येक for (चलवृत्यानेक)
४. पंचाशतः for (पंचाशत्)
(ग) ५. दृग्मंडल (ङ) for (दग्मंडल)
६. क्षिपा for (क्षपा)
(च) १. विक्षेपाप for (दग्क्षेपाप) २. विमंडलानां for (विमंडलान्यं)

यत्स्पष्टीकरणाद्यं गोलादुत्क्षेपतत्कृतं सर्वं गोलाध्यायः।
सप्तत्यार्याणामेक विंशोयम् ॥ ७० ॥
मध्याद्यमिह यदुक्तं तत्प्रत्यक्षमिव दर्शयति यस्मात्।
तस्मादाचार्यत्वं गोलविदो भवति नान्यस्य ॥ ७१ ॥
आचार्येण ज्ञातः श्रीषेणार्यभटविष्णुचंद्राद्यैः।
गोले यस्मात्तस्माद् ब्राह्मे गोलः कृतः स्पष्टः ॥ ७२ ॥
गणितज्ञो गोलज्ञो गोलज्ञो ग्रहगतिं विजानाति।
यो गणितगोलबाह्यो जानाति ग्रहगतिं सः कथम् ॥ ७३ ॥

इति ब्रह्मगुप्ते गोलाध्यायः (२१ अध्यायः समाप्तः)

एक विंशतितमः समाप्तः

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७०. (घ) १. दुत्प्रेक्ष (ग) दुत्प्रेक्ष्य (ङ) for (दुत्क्षेप)
२. (वि०—यह दूसरी पंक्ति का आरम्भिक शब्द है) (ग) (ङ)
(ग) ३. सर्वा for (सर्वं) ४. समाप्ति सूचक ॥छः॥ ॥छः॥ ॥छः॥
(च) १. दुत्प्रेक्षतत्कृतं for (दुत्क्षेपतत्कृतं)
(ङ) +इति श्री ब्राह्मस्फुट सिद्धान्ते गोलाध्यायो नामैकविंशतितमो ऽध्यायः+
(वि०—वस्तुतः गोलाऽध्याय यहां ७० वें श्लोक पर समाप्त हो गया है। परन्तु उपर्युक्त प्रति में यन्त्राध्याय के पहले तीन श्लोक मिलाकर ७३ पर समाप्त किया है)

७१. (घ) १. गोलो भवति for (गोलविदो भवति) (वि०—इसकी क्रमसंख्या १ है)
(ङ) वि०—यह 'यन्त्राध्याय' का प्रथम श्लोक है)

७२. (घ) १. आचार्यैर्न (ङ) for (आचार्येण) (ग) २. ज्ञाता for (ज्ञातः)
३. 'विष्णु' पद लुप्त है। ४. गोलो (ङ) (च) for (गोले)
५. ब्राह्मो (ङ) for (ब्राह्मे) (वि०—इसकी क्रमसंख्या २ है)
१. आचार्यैर्न for (आचार्येण) (ङ) (वि०—यह यन्त्राध्याय का द्वितीय श्लोक है)

७३. (घ) १. इति भट्ट जिष्णुसुतब्रह्मगुप्त विरचिते ब्रह्मस्फुट सिद्धांतो गोलाध्यायः एक विंशतितमः। for (इति ब्रह्मगुप्ते गोलाध्यायः)
(ग) २. ग्रहति for (ग्रहगतिं) ३. स (ङ) (च) for (सः)
१. ये पद लुप्त है (वि० —इसकी क्रमसंख्या ३ है)
(च) १. इति भट्ट जिष्णुसुत ब्रह्मगुप्त विरचिते ब्राह्मे स्फुटसिद्धांतो गोलाध्यायः एक विंशतितमः for (इति ब्रह्मगुप्ते गोलाध्यायः २१ अध्यायः समाप्तः)
(ङ) (वि०—यह यन्त्राध्यायः का तीसरा श्लोक है)

अथ यन्त्राध्यायो नाम

द्वाविंशः

कालस्य[2] परिच्छेदः[4] कर्तुं यंत्रं विना[1] यतो शक्यः[3] ।
संक्षिप्तं स्पष्टार्थं यंत्राध्यायं ततो वक्ष्ये ।। १ ।।
सप्तदशकालयंत्राण्यतो धनुस्तुर्यगोलकश्चक्रम्[4] ।
यष्टि[5]शंकु[1]र्घटिका कपालकं कर्त्तरि[2]कीटम्[3] ।। २ ।।
सलिल[1]भ्रमो[2]वलंबः कर्णाछाया[3] दिनार्द्धमर्कोक्षः[6] ।
नव[4]काल ज्ञानार्थं तेषां[5] संसाधानान्यष्टौ ।। ३ ।।

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१. (घ) १. विंना (ग) (च) (ङ) for (विना)
(ग) २. गोलस्य (ङ) for (कालस्य)
३. यतोऽशक्यः (ङ) for (यतोशक्यः)
(वि०—इसकी श्लोक संख्या ४ है)
(ङ) (वि०—श्लोक संख्या ४ है इसके पूर्ववर्ती तीन श्लोकों को गोलाध्याय के अंत में रख दिया गया है)
४. परिच्छेदः for (परिच्छेद)

२. (घ) १. वंटिका for (घंटिका) २. कर्त्तरी (ग) (च) (ङ) for (कर्त्तरि)
३. फीटं (ग) पीठम् for (कीटम्)
(ग) ४. गोलकं चक्रम् for (गोलतश्चक्रम्)
५. यष्टिः (च) (ङ) for (यष्टि)
(वि०—इसकी श्लोक संख्या ५ है)
(च) ३. फीटा for (कीटम्)
(ङ) ३. पीठम् for (कीटम्)

३. (ग) १. सलिलं (ङ) for (सलिल) २. वमो for (भ्रमो)
३. कर्णश्छाया (ङ) for (कर्णाछाया) ४. नय for (नव)
५. यहां अनुस्वारलुप्त है ।
(वि०—इसकी श्लोक संख्या ६ है)
(च) २. ऽवलंबः for (वलंबः) ६. मर्क्कोक्षः for (मर्कोक्षः)
(ङ) २. भ्रमोऽवलम्बः for (भ्रमोवलंबः)
६. मर्कोऽक्षः for (मर्कोक्षः) ४. नल for (नव)

[1]सलिले न समं साध्यं [1]आमणवृत्तमवलंब [4]केनोर्द्धम् ।
[5]तिर्यंक [2]कर्णोनान्यैः कथितैश्च नव [3]प्रसाध्यति ।। ४ ।।
धार्यं धनुस्त[1]थाग्रछायासाम्यं यथोन्नता [2]भागाः ।
दिनगतशेषा घटिका[4]श्चलंबमुक्ता [3]धनुर्मध्यात् ।। ५ ।।
[4]धार्यें समं तथा वा ज्या छाया [1]पृथगा यथा भवति [2]अग्रादम् ।
[6]शक घटिका ज्यामध्य[3]छायया [5]मुक्ता ।। ६ ।।
[4]घटिका स्वशंकुभागैः [7]पृष्टगतैं [5]लंब [6]भूसमं समज्यार्द्धात् ।
[1]सशिति [2]शतांशकं [3]चक्रास्यार्द्धं धनुर्यंत्रम् ।। ७ ।।

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४. (घ) १. भ्रमेण (ग) (ङ) for (आमण)
२. तिर्यंक्कर्णोनान्यैः (ग) (ङ) तिर्यक्‌कर्णोनान्यैः for (तिर्यंककर्णोनान्यैः)
३. प्रसाध्यानि (ग) प्रवक्षामि for (प्रसाध्यति)
(ग) ४. केनोर्ध्वम् (ङ) for (केनोर्द्धम्) ५. तिर्यक् (ङ) for (तिर्यंक)
(वि०—इसकी श्लोक संख्या ७ है)
(च) ५. तिर्यकर्णोनान्यैः for (तिर्यंककर्णोनान्यैः)
३. प्रसाध्यानि for (प्रसाध्यति) (ङ) ३. प्रवक्ष्यामि for (प्रसाध्यति)

५. (ग) १. तथान्य for (तथाग्र) (वि०—इसकी श्लोक संख्या ८ है)
२. भागम् for (भागाः) ३. धनुर्मुक्तान् for (धनुर्मध्यात्)
(ङ) १. तथाऽन्यत् for (तथाग्र) ४. स्वलम्बभुक्ता for (श्चलंबमुक्ता)

६. (घ) १. पृष्टगा (ग) for (पृथगा) २. (वि०—दूसरी पंक्ति का आरम्भिक पद) (ग)
३. छायाया (ग) छाया यथा for (छायया) (ग) ४. धार्यं (ङ) for (धार्यें)
२. अग्रादश for (अग्रादम्) ५. भुक्ताः ।।९।। (ङ) for (मुक्ता)
(वि०—इसकी श्लोक संख्या ९ है) (च) ३. छायाया for (छायया)
(ङ) १. मध्यगा for (पृथगा) २. अग्रादिष्टा for (अग्रादम्) ६. 'शक' लुप्त

७. (घ) १. सशीति (ग) साशीति (ङ) for (सशिति)
२. शतांशाकं (ग) शाकं (ङ) for (शतांशकं)
३. चक्रस्यार्द्धं (ग) for (चक्रास्यार्द्धं) (ग) ४. घटिकाः (च) for (घटिका)
५. लंब (ङ) for (लंब) ६. 'समं' पद लुप्त है ।
(वि० इसकी श्लोकसंख्या १० है)
(च) १. सशीति for (सशिति) २. शतांशाकं for (शतांशकं)
३. चक्रस्यार्द्धं for (चक्रास्यार्द्धं) (ङ) ७. पृथग्गतैं for (पृष्ठगतैं)
६. भू for (भूसमं)

मध्यादि[३]नोन्नतांशैं दिनार्द्ध नाड्यो[४] वदंति तुल्या ये[५]।
ते सू[६]र्यास्त छा[१]दष्ट छाया समान य[२]तः ।। ८ ।।
जीवा स्वा[६]होरात्रं परिक[४]ल्पाग्रा न[१]तोन्नतत्रिज्या ।
अनुपातात्[५] तत्कार्या सू[२]र्यगोलके च[३]क्रं चैवम् ।। ९ ।।
दिन घटिकांकितपृ[३]ष्टे व्यस्त न[४] तज्याग्रो[५]न्नतज्या[१]।
च[२]दिग्मध्ये च श[६]लाकातछायाग्रं[७] न तानाड्यः ।। १० ।।

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८. (घ) १. द्दष्ट (ग) छायाद्दष्ट for (छादष्ट) २. समानयत for (समानयतः)
(ग) ३. मध्यदिनोन्नतांशै for (मध्यादिनोन्नतांशै)
४. नाडी for (नाड्यो) ५. तुल्यायै for (तुल्याये)
६. मूर्षास्त for (सूर्यास्त) (वि०—इसकी श्लोक संख्या ११ है)
(च) १. छाद्दष्ट for (छादष्ट) २. युतः for (यतः)
(ङ) ३. मध्यदिवसोन्नतांशै for (मध्यादिनोन्नतांशै)
४. नाडीर्वदन्ति for (नाड्योवदन्ति) ६. ते मूर्खास् for (ते सूर्यास्)
१. तच्छाया इष्ट for (तछादष्ट)
९. (घ) १. अतो (ग) नतेन्नत for (नतोन्नत) २. स्तुर्या (ग) स्तुर्य for (सूर्य)
३. चक्रके (ङ) for (चक्रे)
(ग) ४. प्रकल्प्यग्रो for (परिकल्पाग्रा)
५. अनुपातातात्कार्या for (अनुपातातुतत्कार्या)
(वि०—इसकी श्लोक संख्या १२ है)
(च) १. न्नतोन्नतत्रिद्या for (नतोन्नतत्रिज्या) २. स्तुर्यगोलके for (सूर्यगोलके)
(ङ) ६. जीवां स्वाहोरात्रे for (जीवास्वाहोरात्रं)
४. (परिकल्याग्रा) for (परिकल्पाग्रा)
१. अतोन्नतविज्याः for (नतोन्नतत्रिज्या)
२. कार्यास्तुर्यगोलके for (कार्यासूर्यगोलके)
१०. (घ) १. (च) (वि०—पहली पंक्ति का अंतिम पद) (ङ)
२. 'दिग्मध्ये' से आरम्भ (ग) दिनमध्ये for (दिग्मध्ये)
(ग) ३. पृष्टि for (पृष्टे) ४. व्यस्तनज्याग्र for (व्यस्तनतज्याग्रो)
५. उन्नतज्या च for (ग्रोन्नतज्या) ६. शिलाका for (शलाका)
७. यान्नता नाड्यः for (ग्रं नतानाड्यः)
(वि०—इसकी श्लोक संख्या १३ है)
(ङ) ३. पृष्टे for (पृष्टे)
५. ग्रमुन्नतज्या for (ग्रोन्नतज्या) ७. तच्छायाग्राग्नता for (तछायाग्रंनता)

पृष्टो[१] नेष्टो वेध्यो[७] ज्यामध्यसंस्थाया[२] ।
द्रष्टृचा[३] द्रष्टांतरं[४] न तज्या[६] धनुषि छायोन्नत ज्याया[५] ॥ ११ ॥
ज्यार्द्धे[४] द्रष्टि[१] द्रग्ज्यान्नत[२] जीवा[५] शंकुमुन्नतज्या च[६] ।
धनुषि प्रकल्पयो[७]ज्यां[८] यष्ट्युक्तं[९] नाडीकाद्यंता[३] ॥ १२ ॥
अवलंबनं[३] शलाकां ज्यार्द्धं[१] यष्टि प्रकल्पवा[४] धनुषि ।
भूम्यूच्छायं[२] बहुशो[५] यष्ट्युक्तै[६] रानयेत्करणैः[७] ॥ १३ ॥

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११. (घ) १. धनुषपृष्टेनेष्टौ वेध्यो (ग) धनुष प्रिष्टे नेष्टौवेध्यो for (पृष्टोनेष्टौ वेध्यो)
२. संस्थया (ग) (च) (ङ) for (संस्थाया)
३. द्दष्टृचा (ग) द्दष्टृचा (ङ) for (द्रष्टृचा) (वि—पहली पंक्ति का अंतिम पद)
४. इष्टांतरं (ग) (ङ) for (द्रष्टांतरं) ५. ज्याया: (ङ) for (ज्याया)
(ग) (वि०—इसकी क्रमसंख्या १४ है)
(च) १. धनुषपृष्टे for (पृष्टो) ३. द्दष्टृचा for (द्रष्टृचा)
६. तद्या for (तज्या) ५. ज्याया: for (ज्याया)
(ङ) १. धनुषः पृष्ठे द्रष्ट्रा for (पृष्टो नेष्टो) ७. वेध्या for (वेध्यो)
३. ४. इष्टांतरं for (द्रष्टृचा द्रष्टांतरं) ३. द्दष्टृचा for (द्रष्टृचा)

१२. (घ) १. द्दष्टिं (ग) यष्टि for (द्रष्टि) २. द्दग्ज्या (ग) द्दग्ज्यां (ङ) for (द्रग्ज्या)
३. नाडिकाद्यन्ता (ग) नाडिकाद्यं च for (नाडिकद्यंता)
(ग) ४. ज्यार्द्धं (ङ) for (ज्यार्द्धे) ५. नतजीवां for (न्नतजीवा)
६. ज्यां च for (ज्याच) ७. प्रकल्प्य for (प्रकल्प)
८. योज्यं for (योज्यां) (वि०—इसकी श्लोकसंख्या १५ है)
(च) १. द्दष्टि for (द्रष्टि) २. द्दग्ज्या for (द्रग्ज्या)
५. न्नतजीवां for (न्नतजीवा) ६. ज्याव for (ज्याच)
(ङ) १. द्दष्टे र् for (द्रष्टि) ९. यद्युक्तं for (यष्टच् ुक्तं)

१३. (घ) १. ज्यार्द्धे for (ज्यार्द्धं)
२. भूम्युछायं (ग) भूम्युछाया for (भूम्युच्छायं)
(ग) २. अवलंबन for (अवलंबनं) ४. प्रकल्प्य (ङ) for (प्रकल्प)
५. द्वाहु:शो for (बहुशो) ६. येष्टयुक्तै for (यष्टच् ुक्तै)
(वि० —इसकी श्लोक संख्या १६ है)
(च) २. भूम्युछायं for (भूम्यूछायं) ७. करणै: (ङ) for (करणैः)
(ङ) २. भूम्युच्छाया for (भूम्यूच्छायं) ५. ल्लम्बो for (बहुशो)

यष्टि व्यासार्द्धं[४] तु विवृत्तं भगणांशांकितं[१] कृत्वा[७] ।
यष्टि[२]कीलप्रोते मूले[५] पृथग्भग्रयो[६] विर्द्धे[३] ॥ २१ ॥
ताभ्यां[१] सूर्यशशांकौ वेध्यावर्ग[४]स्थितेन सूत्रेण ।
सूत्रज्यायांतरांशा[२] येतेऽर्क[५] विभाजिता स्थितयः[३] ॥ २२ ॥
सूत्रार्द्धगुणा त्रिज्या यष्टिहृता[१] फलधनुर्द्विगुणितं[२] वा ।
रविचंद्रांतर[४]मिष्टव्यासार्द्धोल्लित[३]वृत्तस्य ॥ २३ ॥
मध्यधृतायायष्टे लंबकशंकुप्रवेशनिर्गमने ।
क्रांतिवशात्प्राच्यपरे मत्साद्याम्योतरे[१] साध्ये ॥ २४ ॥

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२१. (घ) १. भगणांशकांकितं (ग) (च) for (भगणांशांकितं)
२. यष्टी (ग) (ङ) (च) for (यष्टि)
३. विद्धे (ग) विधिः (विधेः) for (विर्द्धे)
(ग) ४. व्यासार्द्धाद्भुवि (ङ) for (व्यासार्द्धंतुवि)
५. मूल for (मूले) ६. प्रथग्रयो (च) for (पृथग्भग्रयो)
(वि०—इसकी श्लोकसंख्या २४ है)
(च) ४. भुविवृत्तं for (तुविवृत्तं)
७. क्रत्वा for (कृत्वा) ३. विर्द्धे for (विर्द्धे)
(ङ) १. भगणांशकं for (भगणांशांकितं) ६. पृथगग्रयो for (पृथग्भग्रयो)
३. बंद्धे for (विर्द्धे)

२२. (घ) १. वाभ्यां for (ताभ्यां)
२. ज्ययांतरांशा (ग) (च) (ङ) for (सूत्रज्यायांतरांशा)
३. स्तिथयः (ग) (च) (ङ) for (स्थितयः)
(ग) ४. वग्र (च) (ङ) for (वर्ग) ५. येनेऽर्क for (येतेऽर्क)
(वि०—इसकी श्लोसंख्या २५ है)
(च) ५. येतेऽर्क्क for (येतेऽर्क)

२३. (घ) १. हृता (ग) (ङ) (च) for (हृता)
२. द्विगुणितं (ग) (ङ) (च) for (द्विगुणितं)
३. व्यासार्द्धोल्लिखित (ग) (ङ) (च) for (व्यासार्द्धोल्लित)
(ग) ४. रविचंद्रांतर (च) for (रविचंद्रातर) (वि०—इसकी श्लोकसंख्या २६ है)
२४. (घ) १. मत्स्याद्यामोत्तरे (ङ) (ग) मतस्याद्याग्योत्तरे for (मत्साद्याम्योत्तरे)
(ग) २. (वि०—इसकी श्लोकसंख्या २७ है)
(च) १. मत्स्याद्यामोत्तरे for (मत्साद्यामोत्तरे)

शंकुतला[1]नांतरयुतिरन्यैकदिशो[2]भुजो भुजस्य कृतिम् ।
दृग्ज्या कर्णकृते[3]: प्रोह्य[4]पदपूर्वापरा कोटि[5]: ॥ २५ ॥
उदयास्तसूत्रशंक्वंतरं हृ[1]तं शंकुनार्क[2]संगुणितम् ।
विषुवच्छायै[3]यं वा दि[4]नोदयास्तमयसूत्रेण ॥ २६ ॥
प्राच्यपरा शंकुतलांतर[4]यु[1]ति समान्यदिशो[2] ।
द्वा[5]दशगुणि[6]ता विषुवच्छाया शंक्वंतरविभक्ता[3] ॥ २७ ॥

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२५. (घ) १. शकुंतलाग्रांतर (ङ) (ग) शंकुतलग्नांतर for (शंकुतलानांतर)
२. दिशा (ग) दिशोर्भुजो (ङ) for (दिशोभुजो)
३. कृतिः (ग) कृतेः (ङ) for (कृतेः) ४. पदं (ग) प्रोंश्चपदं for (पद)

(ग) ५. कोटि for (कोटिः)
(वि०—इसकी श्लोकसंख्या २८ है)

(च) १. शंकुतलग्नांतर for (शंकुतलनांतर) २. दिशौ for (दिशो)
३. कृतेः for (कृतेः) ४. प्रोज्यपद for (प्रोह्यपद)

(ङ) ४. पदं for (पद)

२६. (घ) १. शंक्वंतरहृतं (ग) हृतं for (हृतं)
२. नार्क १२ संगुणितम् (ग) शंकुनार्क संगुणितम् for (शंकुनाऽर्कसंगुणितम्)
३. छायायैवं (ग) विषुवच्छायेव वा for (विषुवच्छायैयं)

(ग) (वि०—इसकी श्लोक संख्या २६ है)
४. विनोदयास्तमयसूत्रेण (ङ) for (दिनोदयास्तमयसूत्रेण)

(च) १. हृतं for (हृतं)
२. शंकुनार्क्क १२ for (शंकुनार्क)
३. विषुवच्छायैव for (विषुवच्छायैयंवा)

(ङ) ३. विषुवच्छायैवं for (विषुवच्छायैयं)

२७. (घ) १. युतिः (च) (ङ) for युति)
२. दिशोः (च) (ङ) for (दिशो)
३. विभक्ताः for (विभक्ता)

(ग) (वि०—इसकी श्लोक संख्या ३० है)
४. द्वयांतरयुति (ङ) for (युति)
५. द्वादभक्ता for (द्वादश) ६. 'गुणिता' पद लुप्त है ।

शंकुप्राच्यपरांतर शंकवग्रं क्यमुदयांतरं याम्ये ।
लब्धगुणं यष्टिगुणं क्रांति ज्यातो रविः प्रागवत् ।। २८ ।।
अपसृतिरन्यशलाका गुणाशलाक्यांतरेण भक्ता भूः ।
भू स्वशलाका गुणिता गुणिताद्रष्टि विभक्ता ।। २९ ।।

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२८. (घ) १. हृतं (ग) for (गुणं)
(ग) २. प्राच्या for (प्राच्य)(वि०—इसकी श्लोक संख्या ३१ है)
३. मुदगंतरं यामे for (मुदयांतरं याम्ये)
(च) १. हृतं (ङ) for (गुणं)
(ङ) ३. मुदगंतरं for (मुदयांतरं)
४. लम्बगुणं for (लब्धगुणं)

२९. (घ) १. शलाक्यं तरेण (ग) शलाकांतरेण (ङ) for (शलाक्यांतरेण)
२. 'गुणिता' लुप्त
३. दृष्टि (ग) द्रिष्टि for (द्रष्टि)
(वि०—इसकी क्रमसख्या ३० है)
(ङ) ६. भूः for (भू)
३. ४. यष्टि विभक्ता गृहाद्यौच्यम् for (गुणिता द्रष्टि विभक्ता)
(ग) (वि०—इसकी श्लोकसंख्या ३२ है)
४. 'गृहाद्यौच्यम्' पंक्ति का अंतिम शब्द । ३. दृष्टि for (द्रष्टि)
५. (वि०—इसकी क्रमसंख्या ३० अंकित है)
४. + 'ग्रहाद्यौ ब्रं' यह पद पृष्ठ के नीचे अन्य हाथ से लिखा हुआ है ।

दृष्ट्या गुणितापसृति दृष्टि विशेषभाजिता भूमिः ।
भूमिस्व द्रिष्टिभक्ता शलाकाया संगुणोत्छ्रायम् ।। ३३ ।।

(च) यह अतिरिक्त श्लोक यहां पृष्ठ के निम्नोपांत पर अन्यहस्तसे लिखा हुआ है ।
१. दृंष्टि for (दृष्टि) २. भूः for (भूमिः)
३. द्रष्टि for (द्रिष्टि)
४. शलाकया (ङ) for (शलाकाया)
५. संगुणोछ्राय (ङ) for (संगुणोत्छ्रायम्)
(वि०—इसकी भी क्रमसंख्या ३० अंकित है)
(ङ) १. दृंष्टि विशेषेण for (दृष्टिविशेष) ७. भूमिः for (भूमि)
३. दृष्टि for (द्रिष्टि)

लंबनिपातांतरकं लंबौच्यांतरविभक्तमधिकगुणम् ।
भूर्लंबांतरगुणिता लंबनिपातांतरविभक्ता ॥ ३० ॥
लब्धोनाद्रक् लम्बोदग्लम्बा दग्रलंबके हीने ।
अधिकेऽधिको ग्रहोच्यं तलाग्रवेध द्वया षष्टचा ॥ ३१ ॥
दृष्टिर्द्रक् लंबगुणा विभाजिताद्यः शलाकया भूमिः ।
सकलशलाका गुणिता भूमिदृष्टचा हतोछ्रायः ॥ ३२ ॥

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३०. (घ) १. भूर्ल्लंबांतर for (भूर्लंबांतर)
२. लंबनिपातांतर for (लंबनिपातांतरकं)
३. विभक्ता: for (विभक्ता)
(वि०—इसकी क्रमसंख्या ३१ है)
(ग) (वि०—इसकी श्लोकसंख्या ३४ है)
(च) १. भूर्ल्लंबातर for (भूर्ल्लंबातर)
४. (वि०—यहां क्रमसंख्या ३१ अंकित है)
३१. (घ) १. लब्धोनाद्दक् (ग) सशेनो द्रिग् for (लब्धोनाद्रक्)
२. लंबोद्दग्लंबा (ग) (च) (ङ) for (लंबोदग्लंबा)
३. ग्रहौच्यं (ग) (च) (ङ) for (ग्रहोच्यं)
४. तलग्रेवेध (ग) तलाग्रवे बध्यया for (तलाग्रवेध)
५. द्वया यष्ट्या (ग) द्रिष्ट्या ॥ ३५ ॥ for (द्वयाषष्ट्या)
(वि०—इसकी क्रमसंख्या ३२ है)
(ग) (वि०—इसकी श्लोक संख्या ३५ है)
(च) १. नाद्दकं for (नाद्रक्) ५. द्वया यष्ट्या for (द्वया षष्ट्या)
६. (वि०— क्रमसंख्या ३२ अंकित है)
(ङ) १. लब्धोनोद्दग् for (लब्धोनाद्रक्) ४. तलाग्रके for (तलाग्र)
५. विद्धया दृष्ट्या for (वेधद्वयाषष्ट्या)
३२. (घ) (वि०—इसकी क्रमसंख्या ३३ है)
१. यष्टियैलग्नंबगुणा (ग) दृष्टिर्द्दग्लंबगुणा for (दृष्टिर्द्रक्लंबगुणो)
२. विभाजिताध: (ग) (च) (ङ) for (विभाजिताद्य:)
३. गुणिता: (च) for (गुणिता) ४, भूमिर्द्दष्ट्या (ङ) for (भूमिदृष्ट्या)
५. हृतोछ्राय: (ग) (च) (ङ) for (हृतोछ्राय:)
(ग) (वि०—इसकी श्लोकसंख्या ३६ है)
(च) १. द्रष्टिद्रक् for (दृष्टिर्द्रक्) ६. (वि०—यहाँ क्रमसंख्या ३३ अंकित है)
(ङ) १. दृष्टिर्द्दग्लम्ब for (दृष्टिर्द्रक्लम्ब)

मित्वाग्रहैकदेशे विद्वेष्ट शलाकया न्ययासर्वम् ।
प्रथमशलकाभक्तं मीत द्वितीया गुणितमौच्यम् ॥ ३३ ॥
षष्टयाहूता शलाका त्रिज्याघात धनु गृहांतरकं ।
यैरूक्तं मूर्खास्ते यतो न द्रष्टयंतरं द्रग्ज्या ॥ ३४ ॥
मूलेद्वंगुलविपुलः शुच्यग्रो द्वादशांगुलोच्छ्रायः ।
शंकुतलाग्रविद्धोग्रवेध लम्बाद्वार्यः ॥ ३५ ॥

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३३. (घ) १. गृहैक (ग) (च) (ङ) for (ग्रहैक) (वि०—इसकी क्रमसंख्या ३४ है)
२. शलाका (ग) शिलाका for (शलका)
३. मिति (ग) मितं (ङ) for (मीत) ४. द्वितीयया for (द्वितीया)
५. गुणिताम्यौच्यम् for (गुणितमौच्यम्)
(ग) ६. देशं (च) for (देशे) ७. विधेष्ट for (विद्वेष्ट)
८. गृहम् for (न्यया) (वि०—इसकी श्लोकसंख्या ३७ है)
(च) ३. मित for (मीत) ४. द्वितिया for (द्वितीया)
५. गुणितम्यौच्यं for (गुणितमौच्यं) (ङ) ७. विद्वेष्ट for (विद्वेष्ट)
३४. (घ) १. यष्ट्याहुता (ग) त्रिज्याहुत for (षष्ट्याहूता)
२. घाता (ग) for (घात) ३. गृंहांतरकम् (च) for (गृहांतरकम्)
४. यैरुक्तं (च) for (यैरूक्तं) ५. दृष्ट्यंतरं (ग) (च) for (द्रष्ट्यन्तरं)
६. दृग्ज्या (ग) दृग्ज्याजुर्द्धायः ॥ ३८ ॥ for (द्रग्ज्या)
(च) १. यष्ट्याहुता for (षष्ट्याहूता) ६. दृग्ज्या for (द्रग्ज्या)
७. (वि०—क्रमसंख्या ३५ अंकित है) (घ)
(ङ) १. यष्ट्याहुताच्छलाका for (षष्ट्याहूताशलाका)
२. घाताद्धनुगृंहान्तरकम् for (घातधनुगृहांतरकम्)
५. दृष्टांतरम् for (द्रष्ट्यंतरं) ७. दृग्ज्या for (द्रग्ज्या)
३५. (घ) १. द्विगुल (ग) द्वयंगुल (ङ) for (द्वंगुल) (वि०—इसकी क्रमसंख्या ३६ है)
२. शूच्यग्रोः (ग) शूच्यग्रो for (शुच्यग्रो)
३. शंकुस्तलाग्र (ग) for (शंकुतलाग्र) ४. दृजुर्धार्यः for (द्वार्यः)
(ग) ५. विपुल for (विपुलः) ६. विधोग्रवेध for (विद्धोग्रवेध)
७. लम्बादृजु र्द्धार्यः ॥ ३९ ॥ for (लम्बाद्वार्यः)
(वि०—इसकी श्लोक संख्या ३९ है)
(च) २. शूच्यग्रोः for (शुच्यग्रो) ८. छायः for (छ्रायः)
७. लम्बादजुर्द्धार्यः (लम्बाद्वार्यः) (वि०—क्रमसंख्या ३६ अंकित है)
(ङ) २. सूच्यग्रो for (शुच्यग्रो) ६. विद्धा for (विद्धो) ४. भृद्द्वयोः for (द्वार्यः)

छायां[४]दृग्ज्या य[५]ष्टिं छयाकर्ण[१] मवलम्बकम् शंकुं ।
परिकल्प्यां[२] शंकु यंत्रे योज्यं घटिकादिषु[३]ष्टयुक्तम् ॥ ३६ ॥
घटिकाकलशार्द्ध[१]कृतिताम्रं[२] पात्रं तले गुरु[३]छिद्रम् ।
मध्येतज्जलमज्जन[४] षष्टया द्युनिशं यथा भवति ॥ ३७ ॥
मध्याध्व्यस्तनतांशैः[१] कपालकं दिवकत्थ[२] सूत्रात् मग्रात्[३] ।
व्यस्तोन्नतांशा[४] विवरे[५] सूत्रैक्या पाततो नाडयः ॥ ३८[६] ॥

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३६. (घ) (वि०—इसकी क्रम संख्या ३७ है)
१. छायाकर्ण (ग) (च) (ङ) for (छयाकर्ण)
२. परिकल्प्या (ग) परिकल्प्य (ङ) for (परिकल्प्यां)
३. घटिकादि पुष्टद्युक्तम् (ग) घटिकादि यद्युक्तम् for (घटिकादि पुष्टयुक्तम्)
(ग) ४. दृग्ज्यां (ङ) for (दृग्ज्या) (वि०—इसकी श्लोकसंख्या ४० है)
(च) २. परिकल्प्य शंकु for (परिकल्प्यांशंकु)
३. घटिकादिसंयुक्तम् for (घटिकादिषु ष्टयुक्तम्)
(वि०—क्रमसंख्या ३७ अंकित है) (ङ) ५. दृष्टि for (यष्टि)
३७. (घ) (वि०—इसकी क्रमसंख्या ३८ है)
१. कलशार्द्धकृति (ग) कलाशतार्द्धा for (कलशार्द्ध)
(ग) २. कृतिताग्रं for (कृतिताम्रं) ३. पृथु for (गुरू)
४. मज्ञान for (मज्जन) (वि०—इसकी श्लोकसंख्या ४१ है)
(च) २. कृतिताम्रं (ङ) for (कृतिताम्रं)
(वि०—इसकी क्रमसंख्या ३८ अंकित है) (ङ) कलसार्धा for (कलशार्द्ध)
३. ऽपृथुच्छिद्रम् for (गुरुछिद्रम्)
३८. (घ) (वि०—इसकी क्रमसंख्या ३९ है)
१. द्व्यस्त (ग) मध्यद्व्यस्तनतांशै for (मध्व्यस्तनतांशैः)
२. दिवक्स्थ (ग) दिक्स्थ (ङ) for (दिवकत्थ)
३. सूत्रमग्राग्रात् (ग) मूत्रमग्रात् for (सूत्रात्मग्रात्)
(ग) (वि०—इसकी श्लोकसंख्या ४२ है)
४. व्यस्तोन्नत्यंश for (व्यस्तोन्नतांशा) (च) १. द्व्यस्त for (ध्व्यस्त)
२. दिक्स्थ for (दिवकत्थ) ३. सूत्रमग्राग्रात् for (सूत्रात्मग्रात्)
४. व्यस्तोन्नतांश for (व्यस्तोन्नतांशा) ५. विववरे for (विवरे)
६. (वि०—क्रमसंख्या ३९ for (३८)
(ङ) १. मध्याद्यस्वनतांशैः for (मध्याध्व्यस्तनतांशैः)
३. सूत्रमध्याग्रात् for (सूत्रात्मग्रात्) ४. व्यस्तोन्नतांश for (व्यस्तोन्नतांशा)

अथवा कपालके नाडिकादिसर्वं धनुष्फक्तं कर्त्तरि यंत्रम् ।
स्थुलं कृतं यतोन्यैर्वदामि ततः ॥ ३६ ॥
दिक्स्थितफलकद्वियुतिस्तले तदग्रस्य सूत्रयोर्मध्ये ।
कीलस्तच्छायाग्रात् कर्त्तयानाडिका स्थूलाः ॥ ४० ॥
दष्टौच्यं समर्पठि यष्टि व्यासार्द्धं मंकितं परिधौ ।
दिग्भगणांशै मूर्द्धन्यग्रा घटिकादि यष्टयुक्तम् ॥ ४१ ॥
नलकोमूले विद्धस्तच्छ्रुति घटिकोद्धृत समुच्छ्रायः ।
लब्धांगुलैस्तुतैर्नाडिका क्रियायंत्रसिद्धिरतः ॥ ४२ ॥

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३६. (घ) १. स्थूलं (ग) (ङ) for (स्थुलं) (वि० — इसकी क्रमसंख्या ४० है)
(ग) २. नाडिकादिकं सर्वम् for (नाडिकादिसर्वं)
३. था धनुष्युक्तं for (धनुष्फक्तं) ४. पत्रम् for (यंत्रम्)
(वि०—इसकी श्लोकसंख्या ४३ है) (च) १. स्थूलं for (स्थुलं)
५. (वि० — क्रमसंख्या अंकित है)
(ङ) ३. यथा धनुष्युक्तं for (धनुष्फक्त)
४. 'कर्त्तरियंत्रम्' दूसरी पंक्ति का आरम्भिकपद ।
४०. (घ) १. स्वच्छायाग्रा for (स्तच्छायाग्रात्) (वि० — इसकी क्रमसंख्या ४१ है)
२. कर्त्तर्या (ग) for (कर्त्तया) ३. नाडिकाः for (नाडिका)
(ग) (वि० — इसकी श्लोक संख्या ४१ है)
(च) २. कर्त्तर्यानाडिकाः for (कर्त्तयानाडिका) (वि० — इसकी क्रमसंख्या ४१ है)
(वि०—इसकी क्रमसंख्या ४१ है)
(ङ) २. कर्त्तयां for (कर्त्तया)
४१. (घ) (वि०—इसकी संख्याक्रम ४२ है)
१. दृष्टौच्यसमं (ग) दृष्टौच्यं (ङ) for (दष्टौच्यं)
२. पीठं (ग) (ङ) for (पठिं) (ग) ३. ष्युक्तम् for (यष्टयुक्तम्)
(च) १. दृष्टौच्यं समं for (दष्टौच्यं सम) २. पीठं for (पठिं)
४. मूर्द्धन्यग्रा for (मूर्द्धन्यग्रा) (वि०—इसकी क्रम संख्या ४२ है)
(ङ) ५ मन्तिकं for (मंकितं) ३. रुक्तम् for (यष्टयुक्तम्)
४२. (घ) (वि०—इसकी क्रमसंख्या ४३ है)
१. विद्धस्त (ग) विद्धस्तच्छ्रुति for (विद्धस्तच्छ्रुति) २. छ्रुति for (छ्रुति)
३. द्धृतस्तदुच्छ्रायः for (समुच्छ्राय) (ग) ४. घटिकोद्धृतः (ङ) for (घटिकोद्धृत)
(वि०—इसकी श्लोक संख्या ४६ है) (च) (वि०—श्लोक संख्या ४३ है)
(ङ) १. तत्श्रुति for (तच्छ्रुति)

घटिकांगुलांतरस्थै वयांगुटकै[1] घंटीधृतैरन्य:[2] ।
उपरिनरोत:[3] शुषिरस्तिर्यक्[4] कीलोस्य मुखमध्ये ।। ४३ ।।
कीलो परिगामिन्यां वीर्यबिद्धं[1] सपारतम[6]लांबु[2] ।
स्त्रवति[3] जलो[4]क्षिपति नरो गुटिकां कुर्मोदयश्चैवम्[5] ।। ४४ ।।
जलपूर्णकृतघटीभिस्तनस्य[1] कर्णादिभिर्जलं श्रिपति[3] ।
पुरुषोन्यर्द्धो[2] सत्वं चक्रचतुष्कस्य कृतमुपरि[4] ।। ४५ ।।

४३. (घ) (वि०—इसकी क्रमसंख्या ४४ है)
१. वीर्यगुटकै (ग) वीर्यगुडकै for (वयांगुटकै)
२· घंटीधृतीरन्य: for (घंटीधृतैरन्य:) ३. उपरिनरांत for (उपरिनरोन:)
(ग) ४. सुषिरस्तिर्यक् (ङ) for (शुषिरस्तिर्यक्)
(वि०—इसकी श्लोक संख्या ४७ है)
(च) १. वीर्या for (वयां)
(वि०—इसकी श्लोकसंख्या ४४ है)
(ङ) १. वीर्याङ्गुलकै for (वयांगुटकै)
३. नरोत: for (नरोन:)
४४. (घ) ((वि०—इसकी क्रमसंख्या ४५ है) १. चीर्याबद्धं for (वीर्यबिद्धं)
२. लावु for (लांबु) ३. स्रवति (ग) (च) (ङ) for (स्त्रवति)
४. जले (ग) (च) (ङ) for (जलो)
५. कूर्मादयश्चैवम् (ग) कूर्मोदयाश्चैवम् ।।४८।। for (कुर्मोदयश्चैवम्)
(वि० —इसकी श्लोक संख्या ४८ है)
(च) २. लावु for (लांबु)
५. कूर्मोदयश्चैवं for (कुर्मोदयश्चैवम्)
(ङ) १. चीर्याद्धं for (वीर्याबद्धं)
२. लाबुतु for (लांबु) ६. द्वपारदम् for (सपारतम)
४५. (घ) (वि०—इसकी क्रमसंख्या ४६ है)
१. स्तनास्य (ग) (ङ) for (स्तनस्य)
२. पुरुषोऽन्यद्वासत्वं (ग) पुरुषोन्यर्द्धासित्व for (पुरुषोन्यर्द्धोसत्वं)
(ग) ३. क्षिपितम् for (श्रिपति) ४. जनमुपरि ।।४९।। for (कृतमुपरि ।।४५।।)
(वि—इसकी श्लोक संख्या ४९ है)
(च) ३. क्षिपति for (श्रिपति)
२. ऽन्यर्द्धा for (न्यर्द्धो) क्रमसंख्या ४६ है ।
(ङ) ३. क्षिपति for (श्रिपति) २. पुरुषोऽन्यर्धासक्त for (पुरुषोन्यर्द्धोसत्वं)

एवं[1] वफवरं नाडिकांगुलैः संस्थिते[2]ऽतरे[3] योज्यम् ।
युद्धानि मल्लगज महिषमेष विविधयुधनृतां[4] च ॥ ४६ ॥
निगिरति[1] च घटिकां गुलांकितैं[5] गंडिकैं[2] मंयुरोऽर्ह्रीं[6] ।
वीर्यभ्रु[3] मेवं गुडकैरूपरिस्थैं ब्रह्मचर्याद्यैः[4] ॥ ४७ ॥
कालोक्षपाप्तिहितः[1] पटहः शब्द[3]करोति घंटा वा[4] ।
एवं यन्त्र[2] सहस्राण्यनेन बीजेन कार्याणि ॥ ४८ ॥

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४६. (घ) १. वधूवरं (ग) (ङ) for (वफवरं) (वि०—इसकी क्रमसंख्या ४७ है ।)
(ग) २. संयुतं for (संस्थिते) ३. चरे (वरे) for (ऽतरे)
४. विवधायुधभृतां च ॥५०॥ (ङ) for (विविधयुधनृतां च)
(वि०— इसकी श्लोक संख्या ५० है)
(च) १. एवंच वरं for (एवं वफवरं)
४. विविधायुधभृतां च for (विविधयुधनृतां च) (वि० —श्लोक संख्या ४७ है)
(ङ) २. संयुता for (संस्थिते) ३. वरे योज्या for (ऽतरे योज्यम्)

४७. (घ) (वि०— इसकी क्रमसंख्या ४८ है)
१. निगिरति गिरति च (ग) निगिरति गिरति for (निगिरति)
२. गंडकैर्मयूरोऽहिम् (ग) खंडकैं for (गंडिकैं)
३. वीर्यमेवं (ग) for (वीर्यभ्रु मेवं)
४. ब्रह्मचर्याद्यैः (ग) ब्रह्मचार्याद्यैः ॥५१॥ (ङ) for (ब्रह्मचर्याद्यैः)
(ग) ५. गुलांकितैः for (गुलांकितैं) ६. मयूरोहिम् for (मंयूरोऽह्रीम्)
(वि०—इस की श्लोक संख्या ५१ है)
(च) २. गंडकैं for (गंडिकैं) ६. मंयूरोऽहिं for (मंयुरोऽर्ह्रीं)
३. वीर्यमेवं for (वीर्यभुमेवं) ४. ब्रह्मचर्याद्यैः for (ब्रह्मचर्याद्यैः)
(वि०—श्लोक संख्या ४८ है) (ङ) २. खण्डकैर for (गंडिकैं)
६. मंयूरोऽहिम् for (मंयूरोऽर्ह्रीं) ३. चीर्यमिवं for (वीर्यभ्रु मेवं)

४८. (घ) (वि०—इसकी क्रमसंख्या ४९ है)
१. कालोत्क्षपाप्तिहितः (ग) कीलीत्क्षेपाभिहतः for (कालोक्षपाप्तिहतः)
२. यंत्रसहस्राण्यनेन (च) (ग) for (यंत्र सहस्राण्यनेन)
३. शब्दं (च) (ङ) for (शब्द)
४. 'वा' पद लुप्त है (वि०—इसकी श्लोकसंख्या ५२ है)
(च) १. कालोक्षेपाभिहतः for (कालोक्षपाप्तिहितः)
(वि०—इसकी श्लोकसंख्या ४९ है)
(ङ) १. कीलोत्क्षेपाभिहतः for (कालोक्षपाप्तिहितः)

लघुदारुमयं चक्रं समशुषिरांतरं पृथगराणाम् ।
अर्धं पारदपूर्णं मध्ये सुल्लिष्ट कृतसंध्यौ ॥ ४९ ॥
तिर्यक् कीलोमध्येध्व्याधारस्थो स्यपारदे ब्रजति ।
छिद्रान्यर्द्धं चक्रकर्मजभ्रमे वांबरे भ्रमति ॥ ५० ॥

४९. (घ) (वि०—इसकी क्रमसंख्या ५० है)
१. लघुदारमयं for (लघुदारमयं)
२. शुषिरांतरां for (शुषिरांतरं)
३. पारतपूर्णं (ग) परेतपूर्णो for (पारदपूर्णं)
४. सुश्लिष्ट (ग) सश्लिष्ट for (सुल्लिष्ट)
(ग) ५. चत्र for (चक्र)
६. दाम for (सम) ७. अर्द्धे for (अर्धं)
८. परिधौ for (मध्ये) १. कृतं संधिः ॥५३॥ for (कृतसंध्यौ)
(वि०—इसकी श्लोकसंख्या ५३ है)
(च) १. लघुदारमयं for (लघुदारूमयं) ३. पारतपूर्णं for (पारदपूर्णं)
४. सुश्लिष्ट for (सुल्लिष्ट) (वि० – श्लोक संख्या ५० है)
(ङ) २. सुषिरारान्तरं for (सुषिरांतरं)
द्वितीयपंक्ति – अर्धेरसेन पूर्णो परिधौ संश्लिष्ट कृतसन्धिः ।
for
अर्धां पारदपूर्णं मध्ये सुल्लिष्ट कृतसंध्यौ ॥

५०. (घ) १. द्व्या (ग) (ङ) for (ध्व्या) (वि०—इसकी क्रमसंख्या ५१ है)
२. ऽस्य पारते for (स्यपारदे) ३. छिद्राण्यूर्ध्वं (ग) (ङ) for (छिद्रान्यर्द्धं)
४. चक्रकमजस्रमेवांबरे (ग) चक्रकमजभ्रमेवांबरे भ्रमति ॥५४॥ for (चक्रकर्मजभ्रमेवांबरे भ्रमति ॥५०॥)
(ग) ५. पारंते for (पारदे)
६. भ्रमति (ङ) for (व्रजति)
(वि०—इसकी श्लोकसंख्या ५४ है)
(च) १. द्व्याधारस्थो for (ध्व्याधारस्थो) २. ऽस्य for (स्य)
५. पारते for (पारदे) ३. छिद्राण्यर्द्धे for (छिद्रान्यर्द्धे)
(वि०—श्लोकसंख्या ५१ है)
(ङ) २. ऽस्य for (स्य)
५. पारदो for (पारदे) ७.+भ्रमति+
४. चक्रमजस्रमे for (चक्रकर्मजभ्रमे) ८. वाम्बरं for (वांबरे)

छिद्रे स्वधिया[५] क्षेप्यं[१] समं तथा[६] पारदं[२] यदा[३] भ्रमति ।
कालसममिष्टमानैश्चक्रकमुतान[४]मूर्द्धं[७] वा ॥ ५१ ॥
कीलस्योपरिगमिभिन[१] तिर्यक्[३] सूत्रके धृतमलाषु[२] ।
प्रागवन्नलके प्रक्षिप्य नाडिका श्रवति[४] पानीये ॥ ५२ ॥

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५१. (घ) (वि०—इसकी क्रमसंख्या ५२ है)
१. च्येप्यं for (क्षेप्यं) (ग) 'क्षेप्यं' लुप्त है ।
२. पारतं (ग) (च) for (पारदं)
३. यथा (ग) (च) for (यदा)
मुत्तान (ग) (च) for (कमुतान)

(ग) ५. स्वधियां समं for (स्वधिया क्षेप्यं)
(वि०—इसकी श्लोक संख्या ५५ है)

(च) १. च्येप्यम् for (क्षेप्यम्)
(वि०—श्लोक संख्या ५२ अंकित है)

(ङ) १. क्षिप्त्वा for (क्षेप्यं)
३. 'यदा' लुप्त ।
६. यथा (for) तथा
४. समुत्तान for (कमुतान)
७. मूर्ध्वं वा for (मूर्द्धं वा)

५२. (घ) (वि०—इसकी क्रम संख्या ५३ है)
१. गामिनि न (ग) गामिनितत्पर्यय for (गमिभिन)
२. मलाबु (ङ) मलाबु for (मलाषु)

(ग) (वि०—इसकी श्लोक संख्या ५६ है)

(च) १. परिगामिनि (ङ) for (परिगमिभिन)
(वि०—श्लोक संख्या ५३ अंकित है)

(ङ) ३. तत्पर्य for (तिर्यक्)
४. स्रवति for (श्रवति)

[6]कर्णज्या क्षिप्र[4]चलन[1]मेव शर[7]मोक्ष[2]शंस्वशबाश्च ।
अध्यायो द्वाविंशो यन्त्रेष्वार्या[5]स्त्रिपंचाशत् ॥ ५३ ॥

[3]इत्ति ब्रह्मगुप्ते यंत्राध्यायः (२२ वां अध्याय समाप्तः)

द्वाविंशः समाप्तः

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५३. (घ) (वि०—इसकी क्रमसंख्या ५४ अंकित है)

१. मेवं (ग) (च) (ङ) for (मेव) २. शंखशब्दाश्च (ग) for (शंस्वशबाश्च)

३. इति ब्राह्मस्फुटसिद्धांते यन्त्राध्यायो द्वाविंशतितमः (ग) for (इत्ति श्री ब्रह्मसिद्धांते यन्त्राध्यायो द्वाविंशः)

(ग) ४. चालन for (चलन) ५. सप्त for (स्त्रि)

(वि०—इसकी श्लोक संख्या ५६ है)

(च) २. शंखशब्दाश्ब for (शंस्वशबाश्च)

(वि०—इसकी श्लोकसंख्या ५४ अंकित है)

३. इति ब्राह्मस्फुटसिद्धांते यंत्राध्यायो द्वाशितितमः for (इत्ति ब्रह्मगुप्ते यंत्राध्यायः (२२ अध्यायसमाप्तः)

(ङ) ६. करणंर्ज्या for (कर्णज्या) २. खशब्दाश्च for (स्वशबाश्च)

७. शरमोक्षणं for (शरमोक्षशं)

३. इति ब्राह्मस्फुट सिद्धान्ते यन्त्राध्यायो नाम द्वाविंशोऽध्यायः for (इति ब्रह्मगुप्ते यन्त्राध्यायः)

अथ मानाध्यायो नाम

त्रयोविंशः

सौरेणाब्द[1] मासतिथयश्चांद्रेण[2] सावनैर्दिवसाः[5] ।
दिनमासाब्द पमध्यानत[3] द्विनार्केंदु[4] मानाख्याम् ॥ १ ॥
मानाति[5] सौरचन्द्रार्क्षसावनानि[1] ग्रहानयनमेभिः ।
मानेन[2] पृथक्‌चत्रुभिर्व्यवहारोत्र[4] [3] लोकस्य ॥ २ ॥
युगववर्ष[1] विषुवदयनत्वहर्निशोर्वृद्धिहानयः[5][2][3] ।
सौरात्तिथि[4] करणाधिकमासोन रात्रपर्वक्रियाश्चांद्रात् ॥ ३ ॥
यसस्य वन[1] प्रमाण ग्रहगत्फपवास[2] सूतक चिकित्साः ।
सावन मानात् ज्ञेया[3] प्रायश्चित्त[4] क्रियाश्चान्या[5] ॥ ४ ॥

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१. (घ) १. सौरेणाब्दा (ग) सौरेणाब्दा (ङ) for (सौरेणाब्द)
२. मासास्तिथय (ग) (ङ) for (मासतिथय)
(ग) ३. मप for (पम)   ४. तद्दिनार्केंदु for (तद्विनार्केंदु)
(च) १. सौरेणाब्द्दा for (सौरेणाब्द)
२. मासास्तिथयश्चांद्रेण for (मासतिथयश्चांद्रेण) ५. दिवसा for (दिवसाः)
२. (घ) १. चान्द्रार्क्ष (ग) चान्द्राक्ष for (चन्द्रार्क्ष)
२. मानैः (ग) च) (ङ) for (मानेन)
३. व्यवहारोऽत्र (ग) संव्यवहाराश्च for (व्यंवहारोत्र)
(ग) ४. पृथक् चतुर्भिः (ङ) for (पृथक्‌चत्रुभि)
(च) १. चान्द्रार्क्ष for (चन्द्रार्क्ष) ४. पृथक्‌चतुर्भि for (प्रथक्चतुभि)
(ङ) ५. मानानि for (मानाति) ३. संव्यवहारोऽत्र for (व्यंवहारोऽत्र)
३. (घ) १. युगवर्षे (ग) युगं वर्ष for (युगववर्ष) २. नंशो for (निशो)
३. हानियः for (हानयः)
(ग) ४. सौरानतिथि for (सौरात्तिथि)
(च) १. युगवर्षं (घ) for (युगववर्ष) ५. विषुचदय for (विषुवदय)
२. नर्स्त्वहर्निशो (ङ) for (नत्वहर्निशो)
४. (घ) १. यज्ञसवन (ग) for (यसस्य वन)
ग्रहत्युपवास (ग) ग्रहगत्युरुवास for (ग्रहगत्फपवास) ३. ज्ञेयाः (ग) for (ज्ञेया)
(ग) ४. प्रायश्चि for (प्रायश्चित्त) ५. चान्याः ॥ ४ ॥ for (चान्या)
(च) १. यज्ञस्य for (यसस्य)   २. ग्रहगत्युपवास for (ग्रहगत्फपवास)
(ङ) १. यज्ञसवन for (यसस्य वन) २. गत्युपवास for (गत्फपवास)
३. सावनमानाज्ज्ञेयाः for (सावनमानात्ज्ञेया) ५. चात्र for (चान्या)

नक्षत्रसावनदिनात् सूर्यादीनां स्वसावन दिनानि ।
यस्मात्तस्मादार्क्षं दुरधिगमं मन्दबुद्धिनाम्[1] ॥ ५ ॥
मानुष्य पित्र[1]देव ब्राह्म[2]यान्यष्टा वमूर्त्तकालस्य ।
उक्तानि ज्ञानार्थं बार्हस्पत्यं[3] नवममन्यत्[4] ॥ ६ ॥
द्वौ द्वौ राशि[1] मकराहृतवः[3] षट् सूर्यगति वशाद्योज्याः[5] ।
शशिर[2]वसन्त ग्रीष्मा वर्षा शरदौ[6] सहेमन्ताः[4] ॥ ७ ॥
भूव्यास गुणोभक्तः कर्क व्यासांतरेण रविकर्ण[2] भूमध्या
द्भू छाया दिर्घत्वं[1] चन्द्रकर्णो[3]नं शेषम्[4] ॥ ८ ॥

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५. (घ) १. मंदबुद्धीनाम् (ग) (ङ) for (मंदबुद्धिनाम्)
(च) १. बुद्धीनां for (बुद्धिनाम्)

६. (घ) १. पित्र्यदेव (ग) पित्र्यदिव्य for (पित्रदेव)
२. ब्राह्मयान्यष्टा (ग) for (ब्राह्मयान्यष्टा)
बर्हस्पत्यं (ग) वार्हस्पत्यं for (बार्हस्पत्यं)
(च) १. पित्र्यदेव for (पित्रदेव)
४. न्नवममन्यत् for (नवममन्यत्)
(ङ) २. दिव्यपित्र्य for (पित्रदेव) ब्राह्माण्यष्टा for (ब्राह्मयान्यष्टा)

७. (घ) १. राशी (ग) (ङ) for (राशि)
२. शशिबसंत (ग) शिशिरवसन्त (ङ) for (शशिरवसन्त)
(ग) ३. मकराहतवः (ङ) (मकराहृतवः)
(च) १. राशी for (राशि)
३. मकराहृतवः for (मकराहृतवः)
४. सहेमन्ता for (सहेमन्ताः)
(ङ) ५. वशाद्भाज्याः for (वशाद्योज्याः) ६. शरदः for (शरदौ)

८. (घ) १. दीर्घवत्वं (ग) दीर्घत्वम् (ङ) for (दिर्घत्वं)
२. 'कर्ण' तक पहली पंक्ति समाप्त (ग) कर्णः (ङ) for (कर्ण)
३. 'कर्णोनम्' तक दूसरी पंक्ति समाप्त (ग) (ङ)
४. 'शेषम्' अगले श्लोक का प्रथम पद है (ग) (ङ)
(च) १ दीर्घत्वं (ङ) for (दिर्घत्वम्)
४. ॥ ८ ॥ शेषं for (शेषं ॥ ८ ॥)

व्यासगुणं[1] दीर्घत्व[9]हृतं[2] शशांककक्षायाम्[3] ।
तमसो व्यास[6] शशि कर्णाद्धृत[5]स्त्रिज्यया[7] गुणा[4]लिप्ता[8] ॥ ९ ॥
रविकर्णं[1] द्धृता स्त्रिज्या[2] कर्क व्यासान्तर[3] हृता शोध्या ।
त्रिज्याभूव्यास वधा[5] च्छशि कर्णं हृतातमो[4] व्यासः ॥ १० ॥
भू व्यासेंदुगति वघात् कर्क व्यासांतरार्कभुक्ति वधम् ।
प्रोह्यें[1]दुमध्यभुक्त्या तिथिगुणयाप्तं तमो व्यासः ॥ ११ ॥
योधिक[1]मासावमरात्रसम्भवज्ञः[6] सर्वेत्रि[2]मानानि ।
आर्याभिर्द्वादशाभि[3]र्मानाध्यायस्त्रियोविंशः[4] ॥ १२ ॥
[5]इत्ति ब्रह्म गुप्ते मानाध्यायः (२३ अध्याय समाप्तः)

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९. (घ) १. यह पंक्ति 'शेषं से आरम्भ है शेषं 'पूव्यास' (ग) 'शेषं भू' लुप्त ।
२. हृतं (ग) (च) (ङ) for (हृतं) ३. कक्ष्यायाम् (च) for (कक्षायाम्)
४. गुणो (ग) (ङ) for (गुणो) ५. हृत (ग) (च) (ङ) for (द्धृत)
(ग) ६. व्यासः (ङ) for (व्यास) ७. स्त्रिज्यो for (स्त्रिज्यया)
८. लिप्ताः for (लिप्ता) ९. दीर्घत्वं for (दीर्घत्व)
(ङ) १. 'शेषं भू' लुप्त ७. स्त्रिज्या for (स्त्रिज्यया)
१०. (घ) ४. हृता (ग) (च) (ङ) for (द्धृता)
२. तृज्या (ग) त्रिज्या (ङ) for (स्त्रिज्या)
३. व्यासांतराहृता (ग) (च) for (व्यासांतरहृता)
४. हृतं (ग) हृतात्तमो for (हृतातमो)
(ग) ५. वधात् शशिकर्णं (ङ) for (वधाच्छशिकर्णं)
(च) २. त्रिज्या for (स्त्रिज्या) ४. हृतातमो for (हृतातमो)
(ङ) ६. व्यासांतराहृता for (व्यासांतरहृता) ४. हृतात् for (हृता)
११. (घ) १. प्रोह्येन्दु for (प्रोह्येन्दु) (च) १. प्रोज्येन्दु for (प्रोह्येन्दु)
१२. (घ) १. योऽधिक (च) for (योधिक) २. वेत्ति (ग) (च) (ङ) for (वेत्रि)
३. द्वादशभि (ग) (च) for (द्वादशाभिर्)
४. स्त्रयोविंशः (ग) (च) (ङ) for (स्त्रयोविंशः)
५. 'इति' से 'समाप्त' तक लुप्त है ।
(ग) ६. सं भावज्ञः for (संभवज्ञः)
(च) ५. 'इति' से 'समाप्त' तक लुप्त है ।
(ङ) ३. आर्याद्वादशभिरयं for (आर्याभिद्वदिशाभिर्)

अथ संज्ञाध्यायो नाम

चतुर्विंशः

यस्मात्संप्रति पत्तिर्न संज्ञया संज्ञितो[1] विना तस्मात् ।
लोकप्रसिद्धसंज्ञारूपादीनां शशांकाद्याः ॥ १ ॥
युगपद्युगा[1]रूदया याम्यायां[3] भास्करस्य वारूण्याम् ।
राव्यर्धात्सौम्याया मस्तमया दिनदलादैंद्राम्[2] ॥ २ ॥
अपमेव[3]कृतः सूर्येंदु पुलिश[1] रोमक वशिष्ट[5] यवनाद्यैः ।
यस्मात्तस्मादेकः सिद्धान्तो ग्रन्थ[2]रचनान्याः[4] ॥ ३ ॥
यदि भिन्नाः सिद्धान्त[2]भास्कर संक्रान्तयोपि भेदसमाः[3] ।
सस्पष्टः पूर्वस्यां विषुवत्पार्को[1]दयो यस्य ॥ ४ ॥
तन्त्र पक्षा[1]गणितं मध्यम गत्युत्तरादयः पञ्च ।
कुट्टाकारो[3] वेधः[4] छन्दश्चित्यू[2]तरं गोलः ॥ ५ ॥

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१. (घ) १. संज्ञिनो (ग) संज्ञिने for (संज्ञितो) (च) १. संज्ञिनो for (संज्ञितो)

२. (घ) १. द्युगादि (ग) युगपत् युगादिरुदयात् for (युगपद्युगारूदया)
२. द्विनदलादैन्द्रचाम् (ग) (ङ) for (दिनदलादैंद्राम्)
(च) १. युगपद्युगादि for (युगपद्युगा) २. द्विनदलादै for (दिनदलाद्यै)
(ङ) १. द्युगादिरुदया for (द्युगारुदया) ३. द्याम्यायां for (याम्यायां)

३. (घ) १. पुलिस for (पुलिश) २. ग्रन्थः (च) for (ग्रन्थ)
(ग) ३. अयमेव for (अपमेव) ४. रचनान्या for (रचनान्याः)
(ङ) ५. वसिष्ठ for (वशिष्ट) २. विरचितो for (ग्रन्थरच)
३. नान्यः for (नान्याः)

४. (घ) १. विषुवत्यार्को (ग) (च) for (विषुवत्पार्को)
(ग) २. सिद्धान्ताः (ङ) for (सिद्धान्त) ३. समाम् for (समाः)
(ङ) ३. विभेद समाः for (पिभेद समाः) १. विषुवत्यर्कोदयो for (विषुवत्पार्कोदयो)

५. (घ) १. तन्त्रपरीक्षागणिते (ग) तन्त्रपरीक्षागणितम् for (तन्त्रपक्षागणितम्)
२. चित्युंत्तरं गोलः (ग) (च) for (चित्यूत्तरं गोलः)
(च) १. तन्त्रपक्षागणिते for (तन्त्रपक्षागणितं) ३. कुदाकरो for (कुट्टाकारो)
(ङ) १. तन्त्र परीक्षा for (तन्त्रपक्षा) ४. वेद्यश्छन्द for (वेधः छन्द)
२. श्चित्युत्तरं गोलः for (श्चित्यूत्तरं गोलः)

यंत्राणिमान संज्ञा[3]श्चैवा[4]ध्यायाश्चतुर्दश ब्रह्मो[1]ध्याय[5]ः ।
चतुर्विंशतिराद्यं द्[2]ंशभिः सहाध्यायैः[6] ॥ ६ ॥
श्री चापवंश[5]तिलके श्री व्याघ्रमुखे नृपे शकनृपाणाम्[1] ।
पंचाशत्संयुक्तैः[2] वर्षशतैः[3] पंचभिरतीतैः[6] ।५५०।[4] ॥ ७ ॥
ब्रह्म[3]स्फुटसिद्धांतैः[4] सज्जनगणित[5]गोलविप्रित्यै[1] ।
त्रिंशद्वर्षेण ततो[2] जिष्णुसुतब्रह्मगुप्ते[6] ॥ ८ ॥
गणितेन फलं[4] सिद्धं[2] ब्राह्म[3]ध्यान ग्रहे यतोध्याये[6] ।
ध्यानग्रहो द्विसप्तत्यार्याणां[5] न लिखितोत्र[1] मया ॥ ९ ॥

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६. (घ) १. ब्राह्मो अध्यायः for (ब्रह्मोध्यायः) (ग) ब्राह्मो for (ब्रह्मो)
(वि०--यहां प्रथम पंक्ति समाप्त)
२. दंशभिः (ग) (च) (ङ) for (द्ंशभिः)
(ग) ३. संज्ञाख्यौ for (संज्ञाश्चै) ४. वाध्याय for (वाध्याया)
५. 'अध्यायः' से दूसरी पंक्ति आरम्भ (ङ)
(च) ५. अध्यायाः for (ध्यायः)
(ङ) ३. ख्याता for (श्चैवा) १. ब्राह्मे for (ब्रह्मो)
६. र्युताध्यायैः for (सहाध्यायैः)

७. (ग) १. नृपानाः for (नृपाणाम्) २. पंचशत्संयुक्तै for (पंचाशत्संयुक्तैः)
३. वर्षशतैः for (वर्षशतैः) ४. '५५०' संख्या लुप्त है।
(घ) ५. श्रीचापविंशतिलके for (श्रीचापवंशतिलके)
६. पंचभिरतीतै for (पंचभिरतीतैः)
(ङ) ३. संयुक्तैर्वर्षशतैः for (संयुक्तैः वर्षशतैः)

८. (घ) १. विप्रीत्यै (ग) वित्प्रीत्यैः for (विप्रित्यै)
२. त्ततो (ग) कृतो (ङ) for (ततो) (ग) ३. ब्राह्मः (ङ) for (ब्रह्म)
४. स्फुटसिद्धांतः (ङ) for (स्फुटसिद्धान्तैः) ५. गणितश्च for (गणित)
६. गुप्तेन (ङ) for (गुप्ते) (च) ५. सज्जनगणित for (सज्जनगणित)
१. विप्रीत्यै for (विप्रित्यै) २. त्ततो for (त्ततो)
(ङ) १. वित्प्रीत्यै for (विप्रित्यै)

९. (घ) १. लिखितोऽत्र (ङ) for (लिखितोत्र) (ग) २. सिद्धं for (सिद्धं)
(च) ८. ब्रह्मे for (ब्राह्मे) (ङ) ४. फले for (फलं)
२. सिद्धिब्राह्मे for (सिद्धंब्राह्मे) ६. यतोऽध्याये for (यतोध्याये)
५. द्विसप्ततिरार्याणां for (द्विसप्तत्यार्याणां)

तिथिभोगनाडिकासु द्विगुणास्त्रिगुणा[1] खे शोध्याः ।
पंचाशीत्यंशोनास्तिथि[2] नाडीशोधयेच्छशिनः[3] ॥ १२ ॥
वेदहतौ नवभक्तौ राश्यादौ दिनकरोडुपकेंद्रम् ।
त्रिगुणं सप्त विभक्तं गजाद्रयोंशा रवेरुच्चम् ॥ १३ ॥
विकला[1] संयुक्त[2] नव वाणा लिप्तिकारवेर्भुक्तिः ।
खनवनगा शीतांशोः पंचत्रिंशद्विलिप्ताश्च ॥ १४ ॥
स्वोच्चोन[1]केंद्रमिनो[2] नवभिर्लिप्ता शतैर्जीवा[3] ।
विषमे भुक्तस्य समे भोग्य[4] सदैव केंद्रपदे ॥ १५ ॥
त्रिंशत्सनवरसेंदुः[1] ॥ १६ ॥
गतभोग्य[2] खंडकांतरे दल ॥ १७ ॥

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१२. (ङ) १. रसगुणोद्धृताः शोध्याः for (स्त्रिगुणा खे शोध्याः)
२. पंचाशीत्यधिको for (पंचाशीत्यंशो)   ३. नाड्यः for (नाडी)

१३. (ङ) १. (वि०—इस श्लोक का उत्तरार्ध—१४ वें श्लोक का पूर्वार्ध भी है)
त्रिगुणं सप्त विभक्तं नगाद्रयोऽशा रवेरुच्चम् ।
विकलाष्टक् संयुक्ता नवबाणा लिप्तिका ५९।८ रवेर्भुक्तिः ॥ १३ ॥
for
(वेदहतौ नवभक्तौ राश्यादौ दिनकरोडुपकेंद्रम् ।
त्रिगुणं सप्त विभक्तं गजाद्रयोंशारवेरुच्चम् ॥ १३ ॥)

१४. (ङ) (वि०—इस श्लोक का पूर्वार्ध, १३ वें श्लोक का उत्तरार्ध भी है)
१. विकलाष्टक् for (विकला)
२. संयुक्ता for (संयुक्त)

१५. (ङ) १. स्वोच्चोनं for (स्वोच्चोन)   २. मितो for (मिनो)
३. शतैस्ततो for (शतैर्जीवा)   ४. भोग्यस्य for (भोग्य)

१६. (ङ) १. त्रिंशत्सनवरसेन्दुर्जिनतिथि विषया गृहार्धचापानाम् ।
अर्धज्याखंडानि ज्याभुक्तैक्यं सभोग्य फलम् ॥ १६ ॥
for
(त्रिंशत्सनवरसेंदुः ॥ १६ ॥)
२. गतभोग्यखण्डकान्तरदलविकलवधाच्छतैर्नवभिराप्तैः ।
तद्युतिदलं युतोनं भोग्यादूनाधिकं भोग्यम् ॥ १७ ॥
for
(गतभोग्य खंडकांतरेदल ॥ १७ ॥)

स्पाप्तांशोना[1] सवितु द्विगुणा[2] ज्याशीतगौः[3] फलं लिप्ताः ।
स्वफलमृणं चक्रार्द्धादूने केंद्रे धिके धनं[4] मध्ये ।। १८ ।।
नगमूहृद्रविभोग्यं खंडं चांद्रं मत्त[1] भागोनं ।
द्विगुणं[2] भुक्तिफलं स्वमृणं स्यात्कुलीरमकरादिकेंद्रे[3] ।। १९ ।।
भांशोर्कफलस्येंदौ रविवद्दिशोद्धृतः[1] स्वोर्के रवि[2] ।
फलमिनवतिथौ[3] चांद्र[4]व्यस्तः[5] स्फुटार्काप्तम् ।। २० ।।
पंचेषु पंचयुगगुणयम चंद्राशुचंद्र[1]केन्द्र भ[2]फलानि ।
[3]द्विद्विद्विद्विकुकुभुवः षटक्षर हिते त[4] सूर्यम् ।। २१ ।।
[1]भान्यश्विन्यादीनि ।। २२ ।।
[2]अर्कोनचंद्रलिप्ता ।। २३ ।।

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१८. (ङ) १. स्वाष्टांशोना for (स्पांप्तांशोना)
२. द्विगुणा for (द्विगुणा) ३. गो: for (गौः)
४. 'धनम्' पद लुप्त है ।

१९. (ङ) १. विव सुलवं for (मत्तभागोनं)
२. 'द्विगुणं' यहां यह पद प्रथम पंक्ति का समापक है ।
३. मकरादिके for (मकरादिकेंद्रे)

२०. (ङ) १. रविवद्द्या द्विशोधिते तथा स्वोच्चे for (रविवद्दिशोद्धृतः स्वोर्के)
२. यहां 'रवि' पद दूसरी पंक्ति का आरंभक है ।
३. नवश्च तिथौ for (नवतिथौ) ४. चांद्रे for (चान्द्र)
५. व्यस्तं for (व्यस्तः)

२१. (ङ) १. चंद्रास्चन्द्र for (चन्द्राशुचन्द्र) २. ज for (भ)
३. द्विकुभुव खरहिते for (द्विद्विद्विद्वि कुकुभवः षटक्षरहिते)
४. तथा सूर्ये······for (तसूर्यम्)

२२. (ङ) १. अर्कोनचन्द्रलिप्ताः खयमस्वरभाजिताः फलं तिथयः ।
गतगम्ये षष्टिगुणे भुक्त्यन्तरभाजिते घटिकाः ।। २२ ।।
for
(भान्यश्विन्यादीनि ।। २२ ।।)
२. भान्यश्विन्यादीनि ग्रह लिप्ताः खखवसूद्धृता लब्धम् ।
भुक्तिहृते गतगम्ये दिवसाः षष्ट्याहते घटिका ।। २३ ।।
for
(अर्कोन चन्द्रलिप्ताः ।। २३ ।।)

व्यर्केंदुफलाक्ताः[1] ॥ २४ ॥
रविचन्द्र योग लिप्ताः[2] ॥ २५ ॥
इति तिथ्यधिकारः ॥

अंगै रुद्रैः सिद्धैर्गजैर्जिनैरर्के[1] वत्सरात् ॥ ६ ॥ ११ ॥ २४ ॥ ८ ॥ २४ ॥
शैलैर्विलैर्गुणै[2]रसवह्निभि[3]र्योजयोद्भौमः[4] ॥ ७ ॥ ६ ॥ ३२ ॥ २६ ॥
शशिनोक्षितैः[1] शराविरंकैः षड्वह्निभिर्हतानंदान् ।
शशिनाद्वियमै[2]श्चतुरविभिर्दिनैर्युतं[3] भवति बुधशीघ्रम् ॥ २७ ॥
रूपेण[1] खेनकुयमै[2]रंगै[3]र्नभसावकरणरव्यब्दात्[4] ।
गुणिता युक्ता वैदैः[5] कुयमैस्त्रियमैर्गुणैश्च[6] गुरुः ॥ २८ ॥

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२४. (ङ) १. रविचन्द्र योगलिप्ताः खखवसुभिर्भाजिताः फलं योगः ।
गतगम्ये षष्टिगुणे गतियोनिभाजिते घटिकाः ॥ २४ ॥
for
(व्यर्केंदुफलाक्ताः ॥ २४ ॥)

२५. (ङ) १. व्यर्केन्दुकला भक्ताः खरसगुणैर्लब्धमूनमेकेन ।
चरकरणानि ववादीन्यगताच्छेषात् तिथिवदन्यत् ॥ २५ ॥
for
(रविचन्द्रयोगलिप्ताः ॥ २५ ॥)

२६. (ङ) १. र्यमैरर्कवत्सरान् गणयेत् for (जिनैरर्कवत्सरात्)
२. विश्वैर्गुणितै for (विलैर्गुणैः)   ३. रष्टवह्निभि for (रसवह्निभि)
४. र्योजयेत् for (र्योजयोद्भौमः)

२७. (ङ) १. शशिना जिनैः रंकैः षड्वह्निभिर्हतादब्दात्
for
(शशिनोक्षितैः शराविरंकैः षड्वह्निभिर्हतानंदान् ।)
२३. द्विपैर्यमैश्चतुरब्धिभिरन्वितं for (द्वियमैश्चतुरविभिर्दिनैर्युतं)

२८. (ङ) १. +१+   २. +२१+   ३. +६+
४. नवभिश्चकरणाब्दाः for (र्नभसावकरणरव्यब्दात्)
५. वेदैः for (वैदैः)
६. यमैश्च भवति गुरुः ॥ २८ ॥
for
(यमैर्गुणैश्च गुरुः ॥ २८ ॥)

शैलैस्तिथिभी रुद्रैर्यम विषयैरस्त[1] सागरैर्गुणिता ।
वसुभिरनलै[2]र्जिनैः खड्ग[3]गुणैश्च शुक्रा[4] भृगोः शीघ्रम् ॥ २९ ॥
शून्येन द्वादशभिर्द्वादशभिः ददिशिभिः[1] खेषुभिस्त्रयोदभिः ।
गुणिता युक्ता[2] रसरवितिथिविषयै[3]र्वंशभिरर्कैः[4] ॥ ३० ॥
गगने ननंद चन्द्रैः[1] कुयमैरसाब्धिभिरं[2] बरेण[3] हृताः[4] ।
रुद्रैर्नृपैः[5] खवेदैर्युक्ता राश्यादिको[6] राहुः ॥ ३१ ॥
सर्वाणि स्थानानि क्रमात्[1]स्वहरैर्नयेदुपर्युपरि[2] ।
एवं रव्यब्दान्ते ग्रहध्रुवा[3]स्तत्परांशाः[4] स्युः ॥ ३२ ॥
पृथगर्को दिग्गुणितो[1] वसुशरचंद्रहृतः[2] फलेन युतः ।
दलितो भौमध्रुवके क्षिप्तः[3] स्यान्मध्यमो भौमः ॥ ३३ ॥
चतुराहतो विवस्वान[1] पृथक्सस्ताहतो[2] न विधृति[3] विभक्तः ।
फलसंयुक्तादेयो[4] ज्ञचलध्रुवके[5] ज्ञशीघ्रं स्यात् ॥ ३४ ॥

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२९. (ङ) १. 'रस्त' पद लुप्त है । २. रनिलै for (रनलै)
३. षड्गुणैश्च for (खड्गुणैश्च) ४. युक्तम् for (शुक्रा)

३०. (ङ) १. 'ददिशिभिः' पद लुप्त है । २. युता for (युक्ता)
३. रसैरब्धिभिस्त्रिविषयै for (रसरवितिथिविषयै)
४. र्राकिः ॥ ३० ॥ for रर्कैः ॥ ३० ॥

३१. (ङ) १. गगनेन नवचंद्रैः for (गगने ननंद चन्द्रैः)
२. रसाब्धिभिः for (रसाब्धिभि) ३. संबरेण for (रंबरेण)
४. हृताः for (हताः) ५. 'नृपैः' पद लुप्त है ।
६. कः पातः ॥ ३१ ॥ for (कः पातः ॥ ३१ ॥)

३२. (ङ) १. क्रमतः for (क्रमात) २. नैयेदुपरि for (नैयेदुपर्युपरि)
३. ध्रुवा for (ध्रुवास्)
५. मध्यमाः स्युस्ते for (तत्परांशाः स्यु)

३३. (ङ) १. दशगुणितो for (दिग्गुणितो) २. चंद्रैर्हृतः for (चंहृतः)
३. क्षेप्यः for (क्षिप्तः)

३४. (ङ) १. ऽब्धिगुणितः for (विवस्वान) २. च सप्ताहतो for (सस्ताहतो)
३. ऽब्धिधृतिभक्तः for (न विधृतिविभक्तः)
४. संयुतो विधेयो for (संयुक्तादेयो)
५. ध्रुवको for (ध्रुवके)

भट ब्रह्माचार्येण[४] जिष्णुतनयेन[६] गणितगोलविदा ।
आर्याष्टसहस्रेण[१] स्फुटसिद्धान्ते[२] कृतो[३] ब्रह्मा[५] ॥ १० ॥
भग्रह[१] युति वतशंकु[२] वित्रिभलग्नाद्रविग्रहोक्तसमः[६] ।[७]
शशिनः[३] कर्मबहुत्वान्नकृतातो[४] भास्करग्रहणे[५] ॥ ११ ॥
आज्ञेयी[१] नैरूत्योरुद्दिष्टदिने[६] स्थितस्य[२] योऽर्कस्य[३] ।
शंकुछाये कथयत्यब्दापि[४] वेत्ति सूर्यंशः[५] ॥ १२ ॥
अत्र[४] मया यन्नोक्तं गोलादप्रेक्ष्यधिमतोह्यं[१] तत्[४][५] ।
आर्यात्र्योदशोऽयं[२] संज्ञाध्यायश्चतुर्विंशः[३] ॥ १३ ॥[४]

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१०. (घ) १. सहस्रेणः (ग) सहस्त्रेण for (सहस्रेण)
२. सिद्धंते (ग) सिद्धांतः (ङ) for (सिद्धान्ते) ३. कृतो (ग) (च) (ङ) for (कृतो)
(ग) ४. ब्रह्माचार्येण for (ब्रह्माचार्येण) ५. ब्राह्मः for (ब्रह्मा)
(च) १. सहस्रेणः for (सहस्रेण), (ङ) ६. जिष्णोस्तनयेन for (जिष्णुतनयेन)

११. (घ) १. नग्रह for (भग्रह) २. नार्च्छिकु for (वतशंकु)
३. शशनः for (शशिनः) ४. बहुत्वन्ने for (बहुत्वान्न)
५. कृतोऽतो (ङ) for (कृतातो), (ग) ६. वित्रिभलग्नात् for (वित्रिभलग्नाद्)
(च) ५. बहुत्वान्नक्ततोऽतो for (बहुत्वान्नकृतातो)
(ङ) २. वच्छंकु for (वतशङ्कु) ७. ग्रहोक्तिसमः for (ग्रहोक्तसमयः)

१२. (घ) १. आज्ञेयीनैज्ञत्यो (ग) आज्ञेयैनैऋत्यो for (आज्ञेयीनैरुत्यो)
२. रुद्दिष्टदिने for (रूद्दिष्टदिने) ३. स्वितस्य योऽर्कस्व for (स्थितस्य योऽर्कस्य)
४. कथयत्या ···(ग) कथयत्यब्दादपि for (कथयत्यब्दापि)
५. सः (ग) (ङ) for (शः), (च) १. आग्नेये for (आज्ञेयी)
६. नैॠत्ये for (नैरुत्यो) २. वेष्टदिने for (रूद्दिष्टदिने)
३. संस्थितस्य for (स्थितस्य) ४. कथयति वर्षादपि for (कथयत्यब्दापि)

१३. (घ) १. दत्प्रेक्ष्य (ग) दुत्प्रेक्ष्य for (गोलादप्रेक्ष्य)
२. आर्यात्रियोदशो (ग) आर्यत्रयोदशायं for (आर्यात्र्योदशोऽयं)
३. चतुर्विशः (ग) for (चतुर्विशः)
(ग) ४. (वि०—यहाँ समाप्तिसूचक ॥छः॥ ॥छः॥ ॥छः॥ अंकित है)
(च) १. गोलादत्प्रेक्ष्य for (गोलादप्रेक्ष्य)
४. धीमती for (धिमतो) २. आर्यात्रियोदशोयं for (आर्यात्र्योदशोऽयं)
३. चतुर्विशः (ङ) for (चतुर्विंशः) (ङ) १. गोलादुत्प्रेक्ष्य for (गोलादप्रेक्ष्य)
४. धीमता for (धिमतो) ५. वोह्यम् for (ह्यंतत्)
(वि०+इति श्रीमदाचार्य जिष्णुसुतब्रह्मगुप्तविरचिते ब्राह्मस्फुटसिद्धान्ते संज्ञाध्यायश्चतुर्विंशतितमः सम्पूर्णतामगमत्+)

गणितं बहुप्रकारं गोलो यंत्राणि यत्र कथितानि ।
स ब्रह्मगुप्तविहितः[1] स्फुट सिद्धांतो[2] स्मृतो ब्रह्म[3] ॥ १४ ॥[4]
सिद्धांतेपि स[1] ब्राह्मयं तपसा भक्तघा[2] वयो महादेवम् ।
आराध्यकर[3] नमस्तस्मै श्री ब्रह्म गुप्ताय ॥ १५ ॥
इति श्री भिलमाचार्य[4]भट[5] जिष्णु सुत ब्रह्मगुप्तविरचिते ब्राह्म-
स्फुटसिद्धान्ते संज्ञाध्यायः
ब्रह्म गुप्त सिद्धांतः समाप्तः ॥

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१४. (घ) १. विहृतः (च) for (विहितः) २. सिद्धांतः (च) for (सिद्धान्तो)
३. ब्रह्मः for (ब्रह्म) (ग) 'ग' में यह श्लोक अंकित नहीं है।

(च) ३. ब्रमः for (ब्रह्म) ४. क्रमसंख्या—१ for (१४)

(ङ) श्लोक अनुपलब्ध है।

१५. (घ) १. संब्राह्मयं for (सब्राह्मयं) २. (च) +च+
३. आराध्य च कर for (आराध्यकर) ४. भिल्लमा for (भिलमाचार्य)
५. भट्ट for (भट)
६. अतिरिक्तपाठ—चतुर्विंशतितमः समाप्तोयं श्रीब्रह्मगुप्तकृतो ब्रह्मस्फुट सिद्धांतः। ब्रह्मसिद्धांतबीजानि। खखखांकं हृताप्येभ्योः। १२००० गतगम्याल्पात एव शून्य यमलहृता। २००, तल्लब्धं त्रि ३ सायक ५ हतं कलाभिरूनौ। सदार्केंदु विधुवद् जीवद्धि।२। हृतंचंद्रोस्वतिथि १५ गुणं च शतशीघ्रं द्वीषु ५२ हतं स्वक् चलेद्विकु १ वेदधहतं च पातकुजज्ञशनिषु २ कल्याणं भूयात् ॥१॥ संवत् १५५४ वर्षे फाल्गुणवदि ४ चतुर्थी रवौ लिखितं भयपुरवास्तव्य रेवातटे वास्तव्य ब्रह्मसिद्धांतः। ग्रंथ संज्ञा।

(ग) 'ग' में यह श्लोक अंकित नहीं है। (ङ) श्लोक अनुपलब्ध है।
चतुर्विंशतितमः समाप्तोऽयं श्रीब्रह्मगुप्तकृतो ब्रह्मस्फुटसिद्धांतः। ब्रह्मसिद्धांत-बिजानि खखखांकं हृताद्येभ्यो १२००० गतगम्याल्पात एव शून्य यमलहृता २०० तलब्धं त्रि ३ सायक ५ हतं कलाभिरूनौ सदार्केंदु विधुवत् जीवेद्धि २ हतं चन्द्रोस्वतिथि १५ गुणं च शतशीघ्रं द्वीषुं ५२ हतं स्वंक्चंलेद्विकु १ वेद ४. हतं च पात कुजशनिषु। २ कल्याणं भूयात् १ श्री ॥ श्री ॥ for (ब्रह्मगुप्त सिद्धांतः समाप्तः)

अथ ब्रह्मगुप्तकृतो ध्यानग्रहोपदेशाध्यायः

॥ ॐ नमः श्री सरस्वत्यै ॥

पंचाशत्संयुक्तं वर्षशत[1] पंचभिर्विना शाकः ।
त्रिस्थोर्कै[2]र्वसुवेदैर्नवचन्द्रैस्ताडितः क्रमशः ॥ १ ॥
[1]समायकसंयुक्तः खजिन २४० विभागो नितः सयमवेदैः ।
मध्यमराशिः शशिविश्वभाजिततोह्यधिक मासा स्युः ॥ २ ॥
तैरुपरितनो युक्तो मासगणोभ्यधिक शेषके[1] शुद्धे[2] ।
घटिकादिकं[3] भचक्राद्रविरवशेषो[4] भवद्भ्रादि[5] ॥ ३ ॥
रूपेण रूपरामैः खसायकैस्ताडितो गुणो[1] युक्तः ।
षड्भिः करैश्च[2] दिग्भिराघटिकां[3] विघटिका स्युः ॥ ४ ॥
खखरसलब्धं घटिकासु नियोजये[1] तिथिध्र[2] ।
रव्यादिकस्तदुदये चैत्रदवेर्क[3] चन्द्रो[4] वा[5] ॥ ५ ॥

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१. (ङ) १. शतैः for (शतै) २. त्रिष्ठोऽर्कै for (त्रिस्थोर्कै)

२. (ङ) १. पंचाब्धियुतोऽधः षष्टिभाजितो लब्धियुक् सरसवेदः ।
for
समायक संयुक्तः खजिन २४० विभागो नितः सयमवेदैः ।
२. मध्यमराशि विश्वैर्विभाजितोऽभ्यधिकमासाः स्युः ॥ २ ॥
for
मध्यमराशिः शशिविश्वभाजिततोह्यधिक मासा स्युः ॥ २ ॥

३. (ङ) १. शेषकः for (शेषके) २. शुद्धः for (शुद्धे)
३. घटादिको for (घटिकादिक) ४. रविशेषो for (खशेषो)
५. भवेद्भ्रादिः ॥ ३ ॥ for (भवद्भ्रादि) ॥ ३ ॥

४. (ङ) १. गणो for (गुणो) २. वेदैर्घृत्या for (करैश्च)
३. वासरघटिका for (दिग्भिराघटिकां)

५. (ङ) १. नियोजयेत् for (नियोजये) २. तिथिध्रुवकाः for (तिथिध्र)
३. चैत्रादावर्क for (चैत्रदवेर्क) ४. चन्द्रौ for (चन्द्रो)
५. च for (वा)

मासगु[१]णो यमगुणितः पृथक् द्वित[२]तोद्वृतः फलसमेतः ।
सार्धा[३]त्तयुतो वसुयम विभक्तः[४] शेषा[५]घोः केन्द्रम् ॥ ६ ॥
चैत्रादिमासगुणिते द्वे नक्षत्रे क्षिपेत्सहस्रांशौ ।
घटिकैकादशयुक्तः[१] सार्द्धेन [२]वपलेन [३]रहिते [४]वा ॥ ७ ॥
नाड्यर्द्धेन समेतं द्वितयं प्रक्षिपेच्च शशिकेन्द्रे ।
रूपं रूप हुता[१]शांखशराश्च तिथिध्रुवे क्रमशः ॥ ८ ॥
वारं दद्यात्प्रतिदिनमब्धिपलोनां परित्यजेन्नाडीम् ।
केन्द्रे क्षिपेद्भूमेकं स[२]द्वियमलं घटीचतुष्कमि[३]तौ ॥ ९ ॥
उज्ज[१]यनी याम्योत्तर रेखायाः प्राग्धनं क्षयः पश्चात् ।
योजन[२]खाष्टि ८० नाडी चरदलमपि सौम्य दक्षिणयोः ॥ १० ॥
ति[१]थियो दशभागो[२] [३]रविधिष्ण्यसमन्विताः शशी[४]मध्यः ।
तिथिभोग नाडिकोनं कर्त्तव्यं शीतगोः केन्द्रः ॥ ११ ॥

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६. (ङ) १. मासगणो for (मासगुणो) २. कुतस्वोद्धृतः for (द्विततोद्धृतः)
३. सार्धाष्ट for (सार्धात्त)
४. ५. विभक्तशेषो विधोः for (विभक्तः शेषाघोः)

७. (ङ) १. युक्ते for (युक्तैः) २. फलेन for (वपलेन)
३. सहिते for (रहिते) ४. च for (वा)

८. (ङ) १. हुताशाः for (हुताशां)

९. (ङ) १. भद्वियमलं for (सद्वियमलं) २. मिते for (मितौ)

१०. (ङ) १. उज्जयिनी for (उज्जयनी)
२. षष्ट्या नाडी for (खाष्टि ८० नाडी)

११. (ङ) १. तिथयो for (तिथियो) २. भागोना for (भागो)
३. रविणा समन्विता for (रविधिष्ण्यसमन्विता)
४. शशी भवति मध्यः for (शशीमध्य)
दूसरी पंक्ति—तिथ्यंशाढ्या शोध्यास्तिथि भोगजनाडिकाः केन्द्रात् ।
for
तिथिभोगनाडिकोनं कर्त्तव्यं शीतगोः केन्द्रः ॥

सप्तह[1]स्त्रिवसुहृतो गुरोः शनिर्द्विगुणितो नवेषु हृतः ।
दि[2]ग्गणितो रसधृतिहृद्राहो लिप्ता सुकृतलिप्ता[3]: ।। ३५ ।।
त्रिगुणो दलितः शुद्धादशयुक[1]सित चलध्रु[2]वे देयः ।
तात्कालिकं चलं स्याद्रविरन्येषां ज्ञशुक्रौ सहः[3] ।। ३६ ।।
मंदांशो[1] नगरवयो भयमाः खनगेंदवः खनंदाश्च ।
यमतत्वानि तद्[2]ूनान्यथाज्ञात्[3]सूर्यवग्द्राह्याः ।। ३७ ।।
रदगुणिता सप्तकृता[1] कुजस्य सौम्यस्य युगगुणा[2] गताः[3] ।
द्विगुणैव[4] फलं सूरेर्द्विगुणा[5] त्रिभाजिताः स्फुजिताः[6] ।। ३८ ।।
श्र्यंशद्भागोनास्य त्रिगुणारविजाय मंदफलं लिप्ताः ।
मंदफलदलोनयुतं शीघ्रोच्चात् शोधयेन्मध्यः ।। ३९ ।।
तस्मात् शीघ्रफलदलं स्वमृणं वामंदसंस्कृतं[1] कृत्वा[2] ।
प्राग्वनमंद[3]फलमतः सकलं मध्यग्रहे[4] कुर्यात् ।। ४० ।।

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३५. (ङ) १. हृत for (हृस्त्रि) २. दिग्गुणितो for (दिग्गणितो)
३. लिप्तः for (लिप्ता)
३६. (ङ) १. स्वद्वादशांशयुक्तः for (शुद्धादशयुक)
२. सितचलं ध्रुवं स्यात् for (सितचलध्रुवे देयः)
३. स्तः for (सहः)
३७. (ङ) १. मंदाशा for (मंदांशो) २. तदूनान्मध्याज्ज्या for (तदूनान्यथाज्ञात्)
३. सूर्यवत् ग्राह्या for (सूर्यवद्ग्राह्याः)
३८. (ङ) १. हृता for (कृता) २. नगगुणा for (युगगुणा)
३. त्रिहृता for (गताः) ४. द्विगुणा हि for (द्विगुणैव)
५. गुणाग्निविभाजिता for (गुणात्रिभाजिताः)
६. स्फुजितः for (स्फुजिताः)
३९. (ङ) १. त्रिगुणा त्रिशद्भक्ता रविजस्य फलस्य मंदफललिप्ताः ।
मन्दफलयुतोनं स्वशीघ्रोच्चाच्छोधयेन्मध्यम् ।। ३९ ।।
for
श्र्यंशद्भागोनास्य त्रिगुणारविजाय मंदफलं लिप्ताः ।
मंदफल दलोनयुतं शीघ्रोच्चात् शोधयेन्मध्यः ।। ३९ ।।
४०. (ङ) १. संस्कृते for (संस्कृतं) २. दत्त्वा for (कृत्वा)
३. प्राग्वन्मंद for (प्राग्वनमंद) ४. मान्दग्रहात् for (मध्यग्रहे)

तस्मत्पृथक् स्थितादपि शीघ्रोच्चाद्दषितशोधिताच्चफलेन ।
सकलेन संस्कृतो मृदुफलस्फुटो जायते स्पष्टः ॥ ४१ ॥
भागीकृतचलकेन्द्रत्रिगुणांश्चद्युद्धृते फलं पिंडा ।
षड्राशधिकेन चक्राद्विशुद्धशेषे तथैव स्यात् ॥ ४२ ॥
पिंडांतरेण गुणितं शाखं खाद्युद्धृतक्रमं वेयम् ।
उत्क्रमविधौ विशोध्यं गतपिंडे शीघ्रफलमेत् ॥ ४३ ॥
पिंडतवि विकरणं गुणौ यदाद्येन पिंडके ततः ।
यल्लभ्यते खवेदैस्तदेव फलमत्र बोद्धयम् ॥ ४४ ॥
पिंडे चतुर्दशे विश्वपिंडगुणितान्मखोद्धृताद्धि कलात् ।
लब्धेन विश्वपिंडो रहितः शेषं फलं भवति ॥ ४५ ॥

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४१. (ङ) १. तस्मात् for (तस्मत्) २. सिताद्दि for (स्थितादपि)
४. विवर्जितात् (स्फुटंकेन्द्रम्) for (आद्दपितशोधिताच्च फलेन)
५. तस्मात् शीघ्र फलेन संस्कृतः for (सकलेन संस्कृतो)
६. 'मृदुफल' पद लुप्त है।

४२. (ङ) १. केन्द्रे for (केन्द्र) २. त्रिगुणे for (त्रिगुणांश्)
३. खाग्न्युद्धृते for (च द्युद्धृते) ४. पिंडः for (पिंडा)
५. षड्राश्यधिके for (षड्राशधिकेन)
६. विशोध्य for (विशोध्य) ७. शेषेण for (शेषे)
८. पिंडः for (तथैव)

४३. (ङ) १. गुणिते for (गुणितं) २. शेषे for (शाखं)
३. खाब्ध्युद्धृते for (खाद्युद्धृत) ४. क्रमाद्देयम् for (क्रमंदेयम्)
५. विधौ for (विधो) ६. पिंडे for (पिंडे)
७. मेतत् for (मेत्)

४४. (ङ) १. पिंडाभावे for (पिंडतवि) विकलं for (विकरणं)
२. गुणयेदाद्येन for (गुणौ यदाद्येन)
३. पिंडकेन for (पिंडके) ४. गण्यंतेतु for (यल्लभ्यते)
५. बोद्धव्यम् for (बोद्धयम्)

४५. (ङ) १. चतुर्दश for (चतुर्दशे) २. विश्वैर्गुणिते for (विश्वपिंडगुणितान्)
३. नखोद्धृते विकलाः for (मखोद्धृताद्धि कालात्)

वसुवेदयुगेति—भौमस्य-४८ । ९४ । १४० । १८४ । २२८ । २७० । ३०६ । ३३६ । ३५६ । ३६६ । ३४२ । २६८ । १०८ । ० ।

(नोट—रेखाङ्कित अङ्क कटे हुए हैं ।)

बुधस्य—३३ । ६६ । ९८ । १२८ । १५४ । १७७ । १९४ । २०४ । २०४ । १८८ । १५७ । १०७ । ३६ । ० ॥

गुरोः—१८ । ३६ । ५० । ६६ । ७८ । ८६ । ९० । ८८ । ८४ । ७४ । ५८ । ३६ । १६ । ० ॥

शुक्रस्य—५० । १०० । १५० । १९९ । २४६ । २९६[1] । ३३३ । ३३१[2] । ४०० । ४१८ । ४०८ । ३४० । १५० । ० ॥

शनेः—११ । २२ । ३१ । ३८ । ४४ । ४६[3] । ४८ । ४६ । ४२ । ३४[4] । २०[5] । । १६ । ६ । ० ॥

रूपगुणा ३१ वाणजिना २४५ । शर ५ । षट्नव ९६ । यम २। गुणा ३ क्रमशः ॥ मध्यमभुक्तिकलाः ॥ स्फुटषट् द्वि २६ रदा ३२ वसु ८ रवेशा १७ ।

पिंडकफलन[1] विभागो भागादि फल[2]गृहे[3] स्वमृणं तत् ।
चलकेंद्र[5]मेष[6]तुलादि[7] संस्थिते[8] कारयेत्क्रमशः ॥ ४६ ॥
वसुवेदायुगनंदाः खवेदचन्द्राः समुद्रवसुचंद्राः ।
वसुयम[1]भलागगनाद्धृत बाहवो रसनभो रामाः ॥ ४७ ॥

(ङ) १. २९० for (२९६) २. ३७१ for (३३१) ३. ४८ (४६)
४. ३५ for (३४) ५. २७ for (२०)

४६. (ङ) १. पिंडफल नवमभागो for (पिंडकफलनविभागो)
२. फलं for (फल) ३. ग्रहेषु वा for (गृहे)
४. स्वमृणम् for (स्वमृणंतत्)
५. चलकेंद्रे for (चलकेन्द्र) ६. मेषादौ for (मेष)
७. तुलादिके for (तुलादि)
८. 'संस्थिते' पदं लुप्त है ।

४७. (ङ) १. वसुयमयमा रसनभोरामा नन्दाग्निरामाश्च ॥ ४७ ॥
for
(वसुयमभलागगनाद्धृत बाहवो रसनभो रामाः ॥ ४७ ॥)

[१]वेदसुरोगोक्षगुणा रसरसरामविलोचना द्विगुणाः ।
[२]वसुरसयमा वसुदिशो नभस्य कुजशीघ्रपिंडा स्युः ॥ ४८ ॥
गुणरामाः षट्करसा वसुनंदा[१]रामलोचन शशांकाः ।
सागर विषयशशांका नगनगचन्द्राः कृतांकभुवः ॥ ४९ ॥
वे वनखा जलधिनखा वसुवसुचंद्रास्तुरंग विषयभुवः ।
तुरगदिशो रसरामा नभश्चपिंडास्तशशिसूनोः ॥ ५० ॥
[१]द्वूरस्त्रिगुणाः खशराः [२]षड्रसा गजनगा [३]रसाप्तौ च ।
[४]खांका [५]भुजंगरसवः सागर वसवः समुद्रनगाः ॥ ५१ ॥
भुजगशरारस रामा[१]रसेंदवश्चंद्रपिंडकाः सूरेः ।
[२]वक्राद्विशुद्धशेषः स्फुटो भवेत्सैंहिकासूनुः ॥ ५२ ॥
खशराः [१]शनंखति तिथयो [२]वसुवसुवंशः शरा विनाशत्याः ।
[३]शशिन वयमागुणसुराः [४]कुनवगुणाः शून्यखांबुधयः ॥ ५३ ॥

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४८. (ङ) १. मोक्षगुणा रसरसरामा विलोचनाब्धिगुणाः ।
for
(वेदसुरोगोक्षगुणा रसरसराम विलोचना द्विगुणाः ।)
२. वसुवसुयमा वसुदिशो नभश्च कुजशीघ्रपिंडाः स्युः ॥ ४८ ॥
for
वसुरसयमावसुदिशो नभस्य कुजशीघ्रपिंडा स्युः ॥ ४८ ॥

४९. (ङ) १. गजविलोचन for (रामलोचन)

५१. (ङ) १. धृतिरसगुणाश्च for (द्वूरस्त्रिगुणाः)
२. षट्क for (षड्)
३. रसाष्टौ for (रसाप्तौ)
४. खाङ्काश्च for (खांका)
५. भुजगवसवः for (भुजंगरसवः)

५२. (ङ) १. 'चन्द्र' पद लुप्त है ।
२. रसेन्दवः पिण्डकाः for (रसेंदवश्चन्द्रपिंडकाः)
३. चक्रा for (वक्रा)

५३. (ङ) १. शतंखतिथ्यः for (शनंखतितिथयो)
२. सागरनन्देन्दवोऽङ्कजिनाः for (वसुवसुवंशः शरा विनाशत्याः)
३. गुणगुणरामाः for (शशिन वयमागुणसुराः)
४. कुनगगुणाः for (कुनवगुणाः)

कुंजरचन्द्र समुद्रागजाभ्रवेदानभो बुधिज्वलनाः ।
गगनशिलीमुखचन्द्रा वियच्चर्चापिंडाः सुरारिगुरौ ।। ५४ ।।
रुद्रायमाः कुगरणा वसुरामाः सागराम्बुनिधयश्चः ।
रसवेदागजवेगजवेदाषडवयो लोचनांबुधयः ।। ५५ ।।
पंचगुरणा सप्तयमा रसचंद्राः षण्णभश्च रविसूनोः ।
अद्यतनस्वसूनयोर्ग्रहयोर्विवरं भवेद्भुक्तिः ।। ५६ ।।
रूपगुरणा बाणजिनाः शराः षडंकायमौ गुरणाः क्रमशः ।
मध्यमभुक्तिकलाः स्युरत्कृतिरदखास्तखेखरा विकलाः ।। ५७ ।।
मंदस्फुट खंडगुरणा भुक्ति खखनवहृतागतिज्या स्यात् ।
ग्रहवत्तत्फलविधिमृदुकेंद्रवशाद्गतौ स्वमृणम् ।। ५८ ।।

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५४. (ङ) १. नभोऽम्बुधि for (नभोबुधि)   २. गुरोः for (गुरौ)

५५. (ङ) १. द्वियमाः for (यमाः)   २. कुगुणा for (कुगरणा)
३. च for (चः)   ४. वसुवेदा for (रसवेदा)   ५. 'वेगज' लुप्त है ।
६. गजवेदाः for (गजवेगजवेदा)   ७. षडब्धयो for (षडवयो)

५६. (ङ) १. पंचगुणाः for (पंचगुरणा)   २. षड्नभश्च for (षण्णभश्च)
३. रूपगुणा ३१ बाणजिनाः २४५ शर ५ षण्णव ९६ यम २ गुणाः ३ क्रमशः ।। ५६ ।।
for
(अद्यतन स्वसूनयोर्ग्रहयोर्विवरं भवेद्भुक्तिः ।। ५६ ।।)

५७. (ङ) १. मध्यमभुक्तिकलाः स्युः षड् द्वि २६ रदाः ३२ खंवसु ८ शका ११ विकलाः
for
(रूपगुणा बाणजिनाः शराः षडंकायमा गुणाः क्रमशः ।)
२. मन्दगुणिताभुक्तिः खखनवविहृताभुक्तिः स्यात् ।। ५७ ।।
for
(मध्यमभुक्तिकला स्युरत्कृतिरदखास्तखेखरा विकलाः ।। ५७ ।।)

५८. (ङ) १. ग्रहवत् तन्मन्दफलं मृदु केन्द्रवशात् स्वमृणं तदूनां च ।
for
(मंदस्फुट खंड गुणा भुक्ति खखनवहृतागतिज्यास्यात् ।)
२. शीघ्रगतिं सङ्गुणयेदेवं शीघ्रस्य खण्डेन ।। ५८ ।।
for
(ग्रहवत्तत्फलविधिमृदुकेन्द्रवशाद्गतौ स्वमृणम् ।। ५८ ।।)

न[1] द्रिहता शीघ्रगतिः संगुणाय शीघ्रभोग्यखंडेन ।
खार्के[2]विभजेल्लिप्ता भौमादीनामतिशीघ्रम् ॥ ५६ ॥
स्वमृणं[1] क्रमोत्क्रमविधौ चतुर्दशो विश्वपिंडको गुणकः ।
हारः[2] ख रसागगतिरे वक्रिणोद्बोधिता चक्रम् ॥ ६० ॥
भुक्तेरपि प्रदलिते द्वे सकलफले द्वे च कारयेद् ग्रहवत् ।
मांदंफलं त्रितयं वक्रोच्चस्य द्वितो व्यस्तम् ॥ ६१ ॥
नवतिथयो ६२ चरखंडा विज्यावत् ॥ ६३ ॥

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५६. (ङ) १. पिंडान्तरेण खार्कैः १२० लिप्ताद्यं स्यात् फलं गतेः शीघ्रम् ।

for

(नद्रिहता शीघ्रगतिः संगुणाय शीघ्रभोग्य खंडेन ।)

२. स्वमृणं क्रमोत्क्रमविधौ चतुर्दश विधिश्च पिंडको गुणकः ॥ ५६ ॥

for

(खार्केर्विभजेल्लिप्ता भौमादीनामतिशीघ्रम् ॥ ५६ ॥)

६०. (ङ) १. हरस्वगतिरेवं वह्निगुणात्याज्ये भुक्ते ।

for

(स्वमृणं क्रमोत्क्रमविधौ चतुर्दशो विश्वपिंडको गुणकः ।)

२. पददलिते द्वे द्वे सुकाले कारयेत् स्फुटा भुक्तिः ॥ ६० ॥

for

(हारः खरसगगतिरेवक्रिणोद्बोधिता चक्रम् ॥ ६० ॥)

नोट—(नवतिपयोधिविभक्ता इत्यादि आर्यापट्कं खण्डखाद्याच्चिन्त्यम्)

६१. (ङ) १. नवतिथयो १५६ ऽष्टि १६ विभक्ताः,
पंचरसा ६५ वसु ८ हृता दश १० त्रिहृताः ।
विषुवच्छगुणिताः स्वदेशजाश्चरदलविनाड्यः ॥ ६१ ॥

for

भुक्तेरपि प्रदलिते द्वे सकल फले द्वे च कारयेद् ग्रहवत् ।
मांदं फलं त्रितयं वक्रोच्चस्य द्वितो व्यस्तम् ॥ ६१ ॥

(ङ) नोट—खण्डखाद्यस्य श्लोकाश्चैते ।

६२. (ङ) १. ज्या केन्द्रं स्फुटभानुं कृत्वा ये राशयश्चरार्धानि ।
भुक्तानि भोग्यगुणिताच्छेषात् खखधृतिहृतात्तुफलम् ॥ ६२ ॥

for

(नवतिथयो ॥ ६२ ॥)

६३. (ङ) गतिपादं पादोनां गतिं विशोध्यास्ततकाल उदये च ।
संसाधितस्य तस्य ग्रहस्य चरकर्म चान्यस्य ॥ ६३ ॥

for

(चरखंडा विज्यावत् ॥ ६३ ॥)

पंचदशहीनयुक्ता ६४ क्रांतिकालाद्विरसगुणाः ।। ६५ ।।
त्रिज्यां विषुवच्छाया घातस्तच्छ्रुति विभाजिताश्चाप्तम् ।
अक्षो नित्यं याम्यो गोलवशाद्दिग्भवेत्क्रांतिः ।। ६६ ।।
क्रांत्यक्षायुति[1] वियोगादक्षणपदैः[2] शोधितै[3]र्दिनदलाभाः[4] ।
भाश्रुतिकृत्योः कृतमनुयुतो नयोस्तत्पदे[5] व्यस्ते ।। ६७ ।।
षड्गुणितागत शेषा नाड्यो दिवसार्द्ध[1] विभाजितात् स्यात् ।
दिनदलकर्ण[2]गुणाप्ता[3] तया त्रिज्यया[4] फलं कर्णः ।। ६८ ।।

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६४. चरदल विनाडिकागति कलावधात् खखरसाग्नि ३६०० लब्धकलाः ।
ऋणमुदयेऽस्तमये धनमुत्तरगोलेऽन्यथा याम्ये ।। ६४ ।।
for
(पंचदशहीनयुक्ता ।। ६४ ।।)

६५. पंचदशहीनयुक्ताश्चरार्ध नाडीभिरुत्तरे गोले ।
याम्ये युक्त विहीना द्विसङ्गुणा रात्रिदिननाड्यः ।। ६५ ।।
for
(क्रांतिकालाद्विरसगुणाः ।। ६५ ।।)

६६. (ङ) १. मिश्रेष्टान्तरगुणिता भुक्तिर्दिवसे निशाद्दले प्रथमे ।
षष्टया विभज्य लब्धं विशोध्य तात्कालिको भवति ।। ६६ ।।
for
(त्रिज्यां विषुवच्छाया घातस्तच्छ्रुति विभाजिताश्चाप्तम् ।
अक्षो नित्यं याम्यो गोलवशाद्दिग्भवेत्क्रांतिः ।। ६६ ।।)

६७. (ङ) १. 'क्षा' लुप्त है ।
२. दक्षपदेः for (दक्षणपदः) ३. शोधिते for (शोधितै)
४. दिनदलेभा for (दिनदलाभाः) ५. नयाकृत्वकर्षः स्यात् ।। ६७ ।।
for
(नयोस्तत्पदे व्यस्ते ।। ६७ ।।)
(क्रान्त्यक्ष युति वियौगाच्चक्रपदात्शोधिते दिनदले भा ।
भाश्रुतिकृत्योः कृतमनुयुतोनयोः कृतिरकर्षस्य ।।)
अयं पाठः साधुः

६८. (ङ) १. दिवसविभाजिता ज्यातत् for (दिवसार्द्ध विभाजितात् स्यात्)
२. कर्मगुणाः for (कर्मगुणा) ३. स्वानया for (प्तातया)
४. त्रिभज्याभक्तं for (त्रिज्यया)
(षड्गुणिता गतशेषा नाड्यो दिवसार्धभाजिता तज्ज्या ।
दिनदलकर्णगुणाऽप्तानया त्रिभज्या फलं कर्णः ।। ६८ ।।) अयं पाठः साधुः

दिनदले[1] कर्णगुणे त्रिज्या[2] निहते[3] श्रवणोधृते फलस्य धनुः ।
द्यु दलगुणं तिथिभक्तं दिनगतशेषावसः[5] क्रमशः ॥ ६९ ॥
ज्याखंडोने[1] शेषे ७० चापानयने नवशत ७१ ।
तिथिनक्षत्र ग्रहसंक्षिप्तोतिस्फुटश्चैवम्[2] ॥ ७२ ॥
दुर्जनकृतघ्न शत्रुप्रभृतीनामेषनि[1]वदातव्यः[2] ।
ध्यानग्रहाधिकारो जिष्णुसुतब्रह्मगुप्तकृतः ॥ ७३ ॥

आर्याः १०९३ ॥ ॥ छः ॥ इति श्री ब्रह्मगुप्त सिद्धान्तः समाप्तः । श्रीरस्तु ॥ छः ॥ स्वस्ति श्री संवत् १६७८ वर्षे शाके १५४४ प्रवर्त्तमाने । उत्तरायने । वसंत ऋतौ । माहामङ्गलप्रदा । वैशाख शुदि १० बुधे, समये श्री राजनगरमध्य वातव्यं······लिखितमस्ति । स्वयं पठनार्थं । पठनार्थं तथा पुत्रपौत्र पठनार्थं तथा परोपकाराय । श्री कृष्णार्पणमस्तु । याद्रिशं पुस्त० । इत्यादि । भग्न द्रिष्टि । त्यादि । श्रीरस्तु ॥

इति समाप्तोऽयं ग्रन्थः ।

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६९. (ङ) १. दिनदलकर्णे for (दिनदलकर्णगुणे) २. त्रिभज्यागुणे for (त्रिज्या)
३. 'निहते' पद लुप्त है ।
४. श्रवणोद्धृते for (श्रवणोधृते) ५. शेषासवः for (शेषावसः)

७०. (ङ) १. ज्याखण्डोने शेषे गुणिते नवभिः शतैरशुद्धहृते ।
क्षेप्याणि शुद्धखण्डैर्गणितानि शतानि नवचापम् ॥ ७० ॥ for
(ज्याखंडोने शेषे ॥ ७० ॥)
इति तिथिनक्षत्रदिनमाद्यादिकसिद्धौ ब्रह्मगुप्तेन ।
द्वासप्तत्यार्याणां संक्षिप्तोऽतिस्फुटश्चैषः ॥ ७० ॥ for
(चापानयने नवशत ॥ ७१ ॥)
२. ७२ वीं संख्या का श्लोक ७३ अंकित है । अगला पृष्ठ देखिये ।

७३. (ङ) इसकी श्लोक संख्या ७२ है ।
वामपार्श्वे लिखितम्] प्रथम दशध्याई पत्र प्रथम लितम् । पश्चात् कियत् दिवसे पंचदशाध्या इति लिखितमस्ति एवं पत्र ॥
१. प्रतिकञ्चुककारिणे for (प्रभृतीनामेष नि) २. न for (व)
३. +इति श्री ब्रह्मगुप्तकृतो ध्यानग्रहोपदेशाध्यायः समाप्तः ॥ +

अकारादिक्रमेण श्लोकानुक्रमणिका